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GEOLOGICAL SURVEY OF OHIO

J. A. BOWNOCKER, State Geologist

FOURTH SERIES, BULLETIN 9

COAL

Part One

COALS OF THE MONONGAHELA FORMATION OR UPPER PRODUCTIVE COAL MEASURES

Part Two

CHEMICAL ANALYSES AND CALORIFIC TESTS OF THE CLARION, LOWER KITTANNING, MIDDLE KITTANNING AND UPPER FREEPORT COALS

GEOLOGY BY

J. A. BOWNOCKER

CHEMISTRY BY

N. W. LORD

E. E. SOMERMEIER

Published by Authority of the Legislature of Ohio, Under the Supervision of the State Geologist

COLUMBUS, OHIO, MAY, 1908

LETTER OF TRANSMITTAL.

To GOVERNOR ANDREW L. HARRIS.

DEAR SIR: — I submit herewith Bulletin No. 9, Fourth Series, Geological Survey of Ohio. This work, which is given to coal, was largely done during the administration of my predecessor, Professor Edward Orton, Jr. The Chemical work is by Professors N. W. Lord and E. E. Somermeier.

The call for information relating to Ohio coals is large, and it is hoped that this report will meet in part the demand and aid in the development and utilization of the fuel resources of our state.

Respectfully submitted,

J. A. BOWNOCKER,
State Geologist.

Ohio State University, May 1, 1908.

ANNOUNCEMENT BY THE STATE GEOLOGIST.

BULLETIN 9.

The last report of the Geological Survey of Ohio treating in a comprehensive way of Coal, was Volume V, published in 1884. It was prepared by the late Dr. Edward Orton, and has proven the most sought after publication of the Survey. Owing in part to the manner of distribution of this report, the supply has long been exhausted, and can now be secured only at the second-hand book stores.

The present Bulletin consists of two parts. Part One is a discussion of the important seams of the Monongahela Formation or Upper Productice Coal Measures. These seams have previously been in part described, but since the reports have long been out of print, it seemed best to review the entire field. Accompanying the discussion will be found the chemical analyses and calorific tests made by Professors Lord and Somermeier. The tests made of the Pittsburg and Pomeroy seams with reference to. their use in coking should be read with profit. These results will be found in Chapter VIII.

A feature of this part of the report is the new assignment made the Pomeroy seam. Heretofore that has always been regarded as the Pittsburg, but recent studies have demonstrated that the coal in question lies above the Pittsburg seam and is the equivalent of the Redstone of Pennsylvania and West Virginia. Credit for this determination belongs very largely to Mr. D. D. Condit.

Part Two consists of analyses and calorific tests of four seams of the Allegheny Formation or Lower Productive Coal Measures. These are the Clarion, Lower Kittanning, Middle Kittanning and Upper Freeport coals. Accompanying the results will be found sections showing the thickness and structure of the seam where sampled.

In the chapter by Professor Lord, "Interpretation of the Chemical and Physical Tests on Coal," the value of coal as shown by its chemical analysis and the effects of the different constituents upon its fuel value are discussed in some detail, as are also the total and available heating values of coals.

The analytical results on the different samples are given in tabular form near the end of the chapter, the composition of the several seams compared and the variations of the seam in different portions of the state shown and discussed. The latter portion of the chapter deals with the improvement of coal by washing and gives the result of a number of tests.

The last chapter is by Professor Somermeier and discusses methods of coal sampling and also of making analyses and calorific tests. It will be seen that the method of sampling has materially changed within the past few years. The discussion of analytical and calorific processes will prove instructive to persons interested in such lines.

Since Volume V was published twenty-four years ago, Ohio has made a prodigious gain in the yearly output of coal. In that year the production was 8,568,070 tons, while in 1906 it exceeded 27,700,000 tons. In 1884 extensive mining in the Wellston field had only begun, now it is approaching the end and the same is true of the Massillon field. It is conservative to say that the great Hocking Valley and Cambridge fields are now at their zenith. This leaves only one large field, the Pittsburg where extensive developments may be made, especially under existing conditions. The coal of Ohio—as of the entire country—is being rapidly consumed.

Finally, grateful acknowledgement is made to those who helped map the coals and collect the samples. Mr. J. E. Hyde gave one summer to mapping and part of a summer to sampling. Mr. D. D. Condit devoted one summer to map work and some weeks to collecting samples. Prof. B. A. Eisenlohr gave much more time to sampling, doing the larger part of this work. Prof. Somermeier spent a portion of one summer collecting samples in the southern part of the state, especially in Lawrence county.

Prof. Orton, under whose administration a large part of this work was done, did nearly all the sampling of the Clarion coal.

The chemical work by Professors Lord and Somermeier constitutes a contribution to the literature treating of the composition and calorific value of Ohio coals.

FORMER PUBLICATIONS OF THE SURVEY.

The work performed by the First, Second and Third organizations of the Geological Survey of Ohio is comprehended in the following list of publications:

First Geological Survey 1837-1838.

Title of Volume.	Date of Issue.	Number of Pages.	Number of Copies.	Geologist in Charge.
First Annual Report..........	1838	134	5,000	W. W. Mather
Second Annual Report........	1838	236	5,000	W. W. Mather

Second Geological Survey 1869-1888.

Title of Volume.	Date of Issue.	Number of Pages.	Number of Copies Printed.	Geologist in Charge.
Report of Progress...........	1869	176	14,500	J. S. Newberry
Report of Progress...........	1870	568	14,500	J. S. Newberry
Report of Progress...........	1871	3	400	J. S. Newberry
Geology of Ohio, vol. I, part I, Geology	1872	680	20,000	J. S. Newberry
Geology of Ohio, vol. I, part II, Paleontology	1873	*401 +49	20,000	J. S. Newberry
Geology of Ohio, vol. II, part I, Geology	1874	701	20,000	J. S. Newberry
Geology of Ohio, vol. II, part II, Paleontology	1875	*431 †59	20,000	J. S. Newberry
Geology of Ohio, vol. III, Geology	1878	958	20,000	J. S. Newberry
Geological Atlas of Ohio......	1879		5,000	J. S. Newberry
Geology of Ohio, vol. IV, Zoology and Botany............	1882	1,070	20,000	J. S. Newberry
Geology of Ohio, vol. V, Economic Geology	1884	1,124	10,000	Edward Orton.
Preliminary Report on Petroleum and Inflammable Gas...	1886	76	2,500	Edward Orton.
Geology of Ohio, vol. VI, Economic Geology	1888	831	15,000	Edward Orton.

Third Geological Survey 1889-1894.

Title of Volume.	Date of Issue.	Number of Pages.	Number of Copies Printed.	Geologist in Charge.
First Annual Report..........	1890	323	10,000	Edward Orton.
Geology of Ohio, vol. VII, part I, Economic Geology	1893	290	2,500	Edward Orton.
Geology of Ohio, vol. VII, (complete including part I..	1894	970	7,500	Edward Orton.

* Pages.
† Plates.

Fourth Geological Survey 1899——.

Title of Volume.	Date of Issue.	Number of Pages.	Number of Copies Printed.	Geologist in Charge.
Bulletin 1—Oil and Gas	1903	320	8,000	Edward Orton, Jr.
Bulletin 2—Uses of Cement	1904	260	6,000	Edward Orton, Jr.
Bulletin 3 { Manufacture of Cements	1904	391	4,000	Edward Orton, Jr.
Bulletin 4 { Limestones and Lime	1906	365	4,000	Edward Orton, Jr.
Bulletin 5—Sand-Lime Brick	1906	79	4,000	Edward Orton, Jr.
Bulletin 6—Bibliography	1906	332	3,500	Edward Orton, Jr.
Bulletin 7 { Nomenclature of Geological Formations	1905	36	3,500	Edward Orton, Jr.
Bulletin 8 { Salt Deposits and Salt Industry	1906	42	3,500	Edward Orton, Jr.
Bulletin 9—Coal	1908	—	6,000	J. A. Bownocker.

DISTRIBUTION OF REPORTS.

First Geological Survey. — These volumes are out of print and rare. They can only be procured from dealers in second-hand libraries and are difficult to obtain even there.

Second Geological Survey. — These volumes were all distributed at the time of their issue. The State retained no stock for meeting future demands, so that no copies of any of these volumes can be obtained from the office of the State Geologist. They can be bought in many second-hand book stores, and from dealers in old libraries, at prices ranging from a few cents to two or three dollars per volume, according to rarity and demand. Volumes V and VI are the rarest and most sought for.

Third Geological Survey.— These volumes were all distributed at the time of issue, except Vol. VII, of which 1,500 were put in the hands of the Secretary of State, for sale at the cost of publication. Of these, a few remain at the date of the publication of this volume. The price is $1.50. To obtain copies, send postal or money order to the Secretary of State, State House, Columbus, Ohio. No other volumes can be obtained from this source.

The other volumes of this series can be procured only from second-hand book and library dealers.

Fourth Geological Survey. — Under the law, copies of these Bulletins can be bought at the office of the State Geologist at the cost of publication. Postal orders, money orders, checks, drafts, or currency must accompany orders. Stamps will not be received.

Bulletin 1—Oil and Gas........................$ 0.65
Bulletin 2—Uses of Hydraulic Cements........... 0.30
Bulletin 3—Manufacture of Hydraulic Cements—Issue exhausted.

Bulletin 4—Lime Resources and Lime Industries....	0.45
Bulletin 5—Lime-Sand Brick Industry............	0.45
Bulletin 6—Bibliography of the Geology of Ohio, and Index to Publications of the Geological Survey of Ohio	0.35
Bulletin 7—Revised Nomenclature of the Ohio Geological publications	0.06
Bulletin 8—Salt Deposits and Salt Industry in Ohio	0.06
Bulletin 9—Coal.	

LAWS UNDER WHICH THE SURVEY OPERATES.

For the information of the public, the law under which the work of the Survey is prosecuted is herewith published:

Laws of Ohio, 1889, Vol. 86, p. 262.

(Senate Bill 409.)

AN ACT

To provide for the extension of the Geological Survey of the State.

Section 1. Be it enacted by the General Assembly of the State of Ohio, That the governor is hereby authorized to appoint a state geologist, whose duty it shall be to continue and extend the investigations already made into the geological structure and resourses of the state. Said state geologist shall be appointed for a term of three years, but he may be removed for cause at any time, and a successor appointed in his stead; and the governor is authorized to fill any vacancy which may occur from any cause, at any time. The compensation of said state geologist shall be at the rate of two hundred dollars per month, for the time actually employed; and said geologist shall have power to employ such assistants as he may need; but in no event shall the salary of the geologist, pay of assistants, and expense of the department, exceed the amount of the expenditure authorized by the general assembly.

Section 2. It shall be the duty of said geologist to study, and determine as nearly as possible, the number and extent of the various formations of the state; to represent the same, from time to time, upon properly constructed maps and diagrams; to study the modes of occurrence and the distribution of the useful minerals and products of these formations; to determine the chemical composition and structure of the same; to investigate the soils and water supply of the state; and to give attention to the discoveries of coal, building stone, natural cement, petroleum, gas and other natural substances of use and value to the state. He may also collect and describe the fossils of the various geological formations of the state; but no expenditure shall be incurred under this head that is not expressly ordered and provided for by the general assembly.

Section 3. The said geologist shall make, on or before the first day in February of each year, a report to the governor, covering the work of the preceding year, and the report shall be transmitted to the general assembly, to be printed in the same manner as other public documents, or as shall be otherwise ordered.

Section 4. The salaries of the state geologist, and the assistants employed by him, together with the traveling and incidental expenses, shall be paid monthly, on presentation of properly itemized vouchers, signed by the governor, out of the state treasury, from the appropriation made for such purpose.

Section 5. There is hereby appropriated from the general revenue fund the sum of one thousand dollars annually, for the purpose above named.

Section 6. This act shall take effect and be in force from and after its passage.

NOAH H. ALBAUGH,
Speaker pro tem. of the House of Representatives.
THEODORE F. DAVIS,
President pro tem. of the Senate.

Passed April 12, 1889.

From the terms of the law, it was evidently intended to provide for the creation of a bureau of geology to which only a portion of the time of the State Geologist should be applied, as the annual appropriation made was much too small to provide the salary of a State Geologist continuously, without making any provisions for office expenses, assistance, etc. It was thought at that time that a few months work per year would be sufficient to maintain the Survey abreast of geological developments.

The powers and duties of the State Geologist under this act were made so broad and general as to permit carrying on almost any work, so that no new legal provision was thought necessary in connection with re-opening the work of the Survey under the Fourth organization.

The law providing for the publication and distribution of reports is as follows:

Laws of Ohio, 1902, Vol. 95, p. 593.

(House Bill, 800.)

AN ACT

To Provide for the Publication and Distribution of the Reports of the State Geologist.

Section 1. Be it enacted by the General Assembly of the state of Ohio, That whenever the state geologist shall have completed a bulletin upon any of the subjects upon which he is authorized to conduct investigation, he shall notify the state printing commission of this fact, and it shall be the duty of this commission to determine the number of copies which shall be printed, and the grade of paper, the kind of binding, and any other details incident to its proper publication.

Section 2. It shall be the duty of said commission to provide for the publication of said bulletin as soon as possible after the completion of the same. The issue shall consist of a minimum number of three thousand copies.

Of these, one thousand copies, after deducting 200 for the State Library, shall be distributed pro rata among the general assembly.

One thousand shall be distributed free by the state geologist in exchange with other surveys, and with individuals whose services have been used in the collection or preparation of the matter for the bulletins. Of this number not more than four hundred may be distributed during the first year after publication, and not more than fifty in any subsequent year.

One thousand copies shall be set aside for binding along with other bulletins from time to time, when a sufficient number of such bulletins have accumulated to make collectively a volume of from 800 to 1,000 pages. They shall be bound, lettered and numbered, to take their place in the series of volumes already published by the survey.

The distribution of the bound volume of the survey shall be in the hands of the state geologist; but the state library shall receive ten copies, each member of

the general assembly one copy, with privilege to draw not to exceed two other copies on application, and public libraries in the state shall be supplied with one copy each. The volumes remaining after these demands have been met, may be distributed among the geological surveys and geological societies of the United States and of foreign countries in exchange for their publications.

Section 3. The board may, at its discretion, order the publication of extra copies in addition to the three thousand already provided for. These extra copies shall be placed in the hands of the state geologist. From these members of the general assembly may, on application, draw up to fifty (50) copies each. Those remaining shall be placed on sale at a price equal to the net cost of printing and binding, which price is to be established by the state supervisor of public printing. The proceeds of such sales shall be accounted for and paid into the state treasury, and the state geologist shall be required by the commission to give suitable bond for the security of the funds thus passing through his hands. The proceeds of such sales shall be credited to the account of the geological survey and shall be used for the prosecution of the further work of the survey without distinction from other funds which the general assembly from time to time appropriates for the survey.

Section 4. The cost of printing, illustrating, electrotyping, binding, et cetera, of said bulletins and said volumes, shall be paid from the general appropriation for state printing.

Section 5. This act shall take effect from and after its passage.

W. S. McKinnon,
Speaker of the House of Representatives.
F. B. Archer,
President of the Senate.

Passed May 12, 1902.

THE SURVEY IN ITS RELATIONS TO THE PUBLIC.

The usefulness of the Survey is not limited to the preparation of formal reports on important topics. There is a constant and insistent desire on the part of the people to use it as a technical bureau for free advice in all matters affecting the geology or mineral industries of the State. A very considerable correspondence comes in, increasing rather than decreasing in amount, and asking specific and particular questions on points in local geology.

The volume of this correspondence has made it necessary to adopt a uniform method of dealing with these requests. Not all of them can be granted, but some can and should be answered. There is a certain element of justice in the people demanding such information, from the fact that the geological reports issued in former years were not so distributed as to make them accessible to the average man or community today. The cases commonly covered by correspondence may be classified as follows:

1st. Requests for information covered by previous publications.—This is furnished where the time required for copying the answer is not too large. Where the portion desired cannot be copied, the enquirer is told in what volume and page it occurs and advised how to proceed to get access to a copy of the report.

2d. Requests for identification of minerals and fossils.—This is done, where possible. As a rule, the minerals and fossils are simple and

familiar forms, which can be answered at once. In occasional cases, a critical knowledge is required and time for investigation is necessary. Each assistant is expected to co-operate with the State Geologist in answering inquiries concerning his field.

3d. Requests from private individuals for analyses of minerals and ores, and tests to establish their commercial value.—Such requests are frequent. They cannot be granted, however, except in rare instances. Such work should be sent to a commercial chemical laboratory. The position has been taken that the Geological Survey is in no sense a chemical laboratory and testing station, to which the people may turn for free analytical work. Whatever work of this sort is done, is done on the initiative of the Survey and not at the solicitation of an interested party.

The greatest misapprehension in the public mind regarding the Survey is on this point. Requests for State aid in determining the value of private mineral resources, ranging from an assay worth a dollar, up to drilling a test well costing several thousand dollars, represent extreme cases. At present there is no warrant for the Survey making private tests, even where the applicant is entirely willing to pay for the service. In many cases individuals would prefer the report of a State chemist or State geologist to that of any private expert, at equal cost, because of the prestige which such a report would carry. But it is a matter of doubt whether it will ever be the function of the Survey to enter into commercial work of this character; it certainly will not be unless explicit legal provisions for it are made.

4th. Requests from a number of persons representing a diversity of interests, who jointly ask the Survey to examine into and publicly report upon some matter of local public concern.—Such cases are not common. It is not always easy to determine whether such propositions are really actuated by public interest or not. Each case must be judged on its merits. The Survey will often be prevented from taking up such investigations by the lack of available funds, while otherwise the work would be attempted.

The reputed discovery of gold is one of the most prolific sources of such calls for State examination. It usually seems wise and proper to spend a small sum in preventing an unfounded rumor from gaining acceptance in the public mind, before it leads to large losses, and unnecessary excitement. The duty of dispelling illusions of this sort cannot be considered an agreeable part of the work of the Survey, but it is nevertheless of very direct benefit to the people of the State.

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MAY, 1908

ASSISTANTS IN COAL MAPPING.

J. E. Hyde, A. M.
D. D. Condit.

ASSISTANTS IN COAL SAMPLING.

Prof. B. A. Eisenlohr.
Prof. E. E. Somermeier.
J. E. Hyde, A. M.
D. D. Condit.

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CHAPTER I.

THE PITTSBURG COAL.[1]

Introduction. As is well known this is the most valuable coal seam in North America. It is found in the states of Pennsylvania, West Virginia, Ohio and Maryland, in all of which it is important. The area of workable coal in this seam is estimated by White at from 6,000 to 7,000 square miles. Orton estimated the area in Ohio alone at 1250 square miles, but this included the Pomeroy coal which is now known to lie above the Pittsburg seam.

Area. The area underlaid by this seam in Ohio forms two distinct fields, an Eastern and a Southern one. The Eastern Field is by far the most important, including nearly the whole of Belmont county, the southeastern part of Harrison, the southern part of Jefferson, the extreme eastern part of Guernsey, the northeastern part of Noble, the northern part of Monroe, and the northern part of Washington counties. The last four counties, however, are of very little importance, though one of them, Monroe, may prove to have valuable deposits of this fuel.

The Southern Field comprises the southwestern corner of Morgan county, the eastern part of Athens, the northern part of Meigs and the southeastern part of Gallia. The Southern Field may be divided into two parts, Morgan, Athens and Meigs counties forming one part and Gallia county the other. The structure of the seam in the two is similar. This field at present, is of minor importance, the fuel being shipped by rail or boat from less than a half dozen places.

Characteristic Structure of the Pittsburg Coal. Over most of the large territory in Ohio and other states, where the Pittsburg coal is found it has a characteristic structure. This is well illustrated below:

Roof coal.
Draw slate.
Breast coal.
Parting.
Bearing in coal.
Parting.
Brick coal.
Parting.
Bottom coal.

So persistent are these divisions that the coal may be identified by them over a wide territory. Occasionally, when the structure of the

[1] For method of sampling see Chapter IX.

seam is in general normal. the parting between the Brick and Bottom coals is wanting. but even in such cases there is commonly a bedding plane between these two members.

In Ohio. however, the seam shows marked variation in structure. Along the river in Jefferson and Belmont counties, where the seam is at its best, the structure is normal; that is it has the succession of coals and partings shown in the general section given above. Farther west, especially along the western border of Belmont county and near the western margin of the Eastern Field the structure of the seam is less constant. There the structure is occasionally normal, but more commonly variations are found. These points are well illustrated in the following sections.

The first section is from Neff Mine No. 2 near Bellaire. In this the structure of the coal may be considerêd normal. and is found in Pennsylvania. West Virginia and Maryland as well as in Ohio:

	Ft.	In.
Roof coal	1	0
Draw slate	0	10
Breast coal	2	3
Shale parting	0	¼
Bearing in coal	0	2
Shale parting	0	1
Brick coal	1	5
Pyrites parting	0	1½
Bottom coal	1	3

Below is another section. which. while differing from the above. may still be classed normal. This section was measured in Dillon Mine No. 2 at Dillonville. Jefferson county:

			Ft.	In.
Roof coal	Coal		0	2½
	Parting		0	1½
	Coal		1	6
	Parting		0	¾
	Coal		0	1½
Draw slate (soapstone)			1	0
Breast coal			2	6½
Parting			0	⅝
Bearing in coal	Coal	1⅝		
	Parting	⅝	0	4½
	Coal	2¼		
Parting			0	⅜
Brick and Bottom coals			2	8

Here the Brick and Bottom coals are not separated by a parting, while the Bearing in coal is thus divided. It will be noted that the structure of the Roof coal is more complex than that found in the last section,—and this structure is the more common one.

Compare these sections with the following one of the same seam found in the Media Mine about three miles southwest of Barnesville:

		Ft.	In.
Draw slate, unmeasured			
Black shale		0	1¾
Breast coal	Coal	0	¾
	Bone coal and pyrites	0	2
	Coal	0	11
Shale		0	1
Bearing in coal		0	5
Shale		0	½
Brick and Bottom coal		3	0

In this section the Breast coal is greatly contracted and subordinate in value while the other parts of the seam are thicker and of increased value.

At Temperanceville in the southwest corner of Belmont county the coal was found as follows:

	Ft.	In.
Shale, unmeasured		
Coal	0	10
Shale and pyrites	0	¾
Coal	3	0

This shows the seam divided into 3 parts, two of coal and one of shale with pyrites. The coal above the parting corresponds to the Breast coal, and is here of minor importance as a source of fuel. The parting itself represents the Bearing in coal with the partings above and below it. The coal below the parting comprises the Brick and Bottom parts of the seam.

The latter two sections are of great importance because they show the transition from the normal structure of the Pittsburg seam to that found farther southwest in Athens and Gallia counties.

Structure of the Pittsburg Coal in Athens and Gallia Counties. Here a marked change occurs. The well-known structure of the seam is wanting and instead a three-fold division is found. This consists of an "Upper bench" and a "Lower bench" of coal separated by a layer of clay or shale. This structure is almost as persistent in Ohio as the well known one in the eastern part of Belmont and Jefferson counties. Usually too, the Lower bench is the more important and in places is the only one mined. It is evident that the structure of the seam is here comparable to that found at Temperanceville, Belmont county. Interesting to note is the fact that at one point in Gallia county the structure of the seam is quite similar to that found farther east. Whether this is of significance or is a lucky accident cannot be stated. These points are illustrated in the following sections:

Section of the Pittsburg coal at Sharpsburg, Athens county:

		Ft.	In.
Shale, unmeasured			
Upper bench	Coal	4	0
	Bone coal	0	2
	Coal	0	4
Clay parting		1	0
Lower bench	Coal	2	10
	Pyrites parting	0	½
	Coal	0	8

Below is a section of the same seam at Bladen, Gallia county on the bank of the Ohio River:

	Ft.	In.
Shale	2	0
Upper bench, Coal	0	4½
Clay	1	0
Lower bench, Coal	2	9

Usually, however, the structure is more complex than shown in the last section. Occasionally, too, the seam shows the ear marks of the structure in Belmont county. The following section measured in Kern's bank near Angel P. O. in Gallia county, illustrates both points:

		Ft.	In.
Roof coal, reported	Coal	1	8
	Soapstone		
	Coal	2	0
Draw slate		2	5
Breast coal or Upper bench	Dirty coal	0	1
	Coal	2	5
	Streak of dirty coal		
	Coal	0	6
	Parting	0	1¾
	Coal	0	11½
Parting	Parting, pyrites	0	1⅝
	Bearing in coal	0	1
	Parting, pyrites	0	¾
Lower bench	Brick coal	0	8½
	Parting	0	¼
	Bottom coal	0	10

Summary. From what has been said it is apparent that the structure of the Pittsburg coal in Ohio presents two distinct phases: (1) That in the eastern counties the structure is usually normal, that is, similar to that found in the great fields east of the Ohio River; (2) that farther southwest in Ohio the structure of the seam is markedly different but persistent in that territory; (3) that between these two phases are intermediate forms which may be regarded transitional.

THE PITTSBURG COAL IN BELMONT COUNTY.

Introduction. This county not only contains the largest quantity of Pittsburg coal of any county in Ohio, but it also contains more coal than any other county in the state.

Every township in the county except Flushing and Kirkwood contains a large area of this seam, and eight townships are almost completely underlain with it. The seam is everywhere of workable thickness and of good quality and hence the county contains a very large quantity of fuel. It is the last of the great coal fields in our state to be developed on a large scale, and it promises to be the most lasting in supply.

Early History. Outcropping as the coal does at so many places, its presence must have been known to residents of the county from the time of its settlement. Probably the fuel began to be used for domestic purposes as early as 1825. Messrs. R. H. O'Neil and Evans Lake are said to have been the pioneer miners and about 1835 the fuel was shipped by river from a mine located on the south bank of McMahon's Creek at Bellaire. At approximately the same time other mines were opened at the north end of Bellaire and West Wheeling.

Between 1835-40 Jacob Heatherington and John Fink opened a mine just south of Bellaire on land now within the corporation limits, and a few years later a mine was opened at Wegee, six miles farther south.

About 1845 the river shipment of coal became active, the fuel being sent as far south as New Orleans. At first the coal was loaded on flats and allowed to drift, but after 1850 the fuel was shipped principally in barges. Much coal was used on the boats for steam purposes and Bellaire became a regular stopping place for loading.

The first railroad mine in the county is said to have been opened in 1858, the locality being one mile west of Bellaire. This mine supplied coal for locomotives and also for shipment. About 10 years later another railroad mine was opened, the location being at Franklin Station 8 miles west of Bellaire. Since that year, other mines have been opened from time to time, but it was not until about the year 1900 that the present boom began.[1]

Belmont county is now the second largest producer of coal in Ohio and probably this lead will be increased from year to year until the county becomes by far the greatest producer in the state.[2]

[1] Historical data by Hon. J. F. Anderson of Bellaire.

[2] Advance reports for 1907 indicate that Belmont county is by far the largest producer in the state.

Statistics. The following figures show the output of the county for several years past:[1]

Year.	Output.	Rank of county in coal production.	Total production of state. Short tons.
1896	919,076	7	12,875,202
1897	827,420	6	12,196,942
1898	1,036,102	6	14,516,867
1899	1,242,383	6	16,500,270
1900	1,345,284	6	18,988,150
1901	1,506,858	6	20,943,807
1902	1,997,956	6	23,519,894
1903	2,725,849	4	24,838,103
1904	3,172,350	2	24,400,220
1905	3,957,980	1	25,552,950
1906	4,266,865	2	27,731,640

In considering the future of Belmont county as a coal producer, it should be remembered that at present the southern two-fifths of her territory do not produce a ton from this seam. This large area, however, is underlain with coal, and in time will be the seat of extensive mining operations. All that is now needed in that territory is transportation, and the valley of Captina Creek furnishes an easy line for railroad construction.

Pease Township. Nearly the whole of this township is underlain with the Pittsburg coal. The Ohio River which forms the eastern boundary of the township has cut far below the seam, and several tributaries of this river have also cut through it. Especially is this true of Wheeling Creek which crosses the township along its southern edge, and a branch of Short Creek in the northwestern corner.

The coal has long been mined along the river front for local use. The fuel is hauled directly from these hills to the iron and steel mills in the valley, thus reducing to a minimum the cost of fuel.

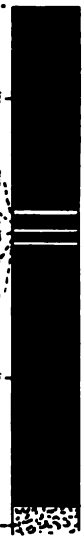
Section 1 shows the coal in the mine which supplies the Aetna-Standard mill with fuel, the location being at the north end of Bridgeport. Occasional streaks of pyrites are found in the lower part of the seam, and one thin smut band was noted. Much the same may be said of the Breast coal. The Bearing in coal is not rejected. The Draw slate overlying the coal is reported to vary from a foot or more in thickness to almost nothing.

[1] Statistics taken from United States Geol. Survey Reports.

The entire output of this mine is used by the mill. It is said that the mine was opened in 1873 and that 268 acres have been worked out. The supply in the hills, however, is adequate at the present rate of consumption to last an indefinite period.

SECTION 1

		Ft.	In.
6. Breast coal,		2	½
5. Parting,		0	⅝
4. Bearing in coal,	Coal, 1½ / Parting, ⅜ / Coal, 1	0	2⅞
3. Parting,		0	¼
2. Brick and bottom coal,		2	7½
1. Clay, unmeasured,			



Chemical analysis and calorific value of Section 1:

Ultimate.		*Proximate.*	
Carbon	71.45	Moisture	3.39(a)
Hydrogen	5.21	Volatile Matter	36.84
Oxygen	11.27	Fixed carbon	51.91
Nitrogen	1.24	Ash	7.86
Sulphur	2.97		
Ash	7.83		
	100.00		100.00

Calorific value .... 7,217 calories.

(a) Moisture in the air-dried sample about 3%.

The sample included parts 2 and 6 only of the section, though all parts, except 1, are mined and used. The sample was 6 inches wide and 2 inches thick and is regarded excellent.

In a ventilating shaft of the old Wheeling Creek Mine in section 3, Professor Brown measured the following section:[1]

	Ft.	In.
Limestone	12	0
Clay	4	0
Pomeroy or 8a coal	0	6

[1] Vol. VI, p. 606.

		Ft.	In.
Clay		1	0
Clay and shale		2	0
Limestone, bedded		16	0
Limestone, nodular		3	0
Clay		2	8
Black shale		0	2½
Roof coal (Pittsburg)		1	0
Clay		0	10
Pittsburg coal	Coal	2	6
	Parting	0	1
	Coal	0	4
	Parting	0	½
	Coal	0	8
	Parting (thin)		
	Coal	0	8
	Parting (thin)		
	Coal	1	3
Limestone		0	4
Clay, unmeasured.			

The coal is quite uniform in thickness and structure throughout the township. Occasionally the Bearing in coal which usually consists of a thin layer of coal with a shale or clay parting above and below, is replaced by a single band of shale. Sometimes the Brick and Bottom coals are separated by a parting of shale, but at other places these coals are directly in contact.

Along Wheeling Creek the coal was formerly coked, but the product contained too much sulphur to enable it to compete with that made at Connellsville.

The Roof coal, as usual, varies in thickness. In places it measures only one foot and elsewhere from two to three feet, but the latter is uncommon. Usually the Roof coal lies directly above the Draw slate. It is not mined.

At Bridgeport the coal is 76 feet above the C. & P. R. R. tracks. It rises rapidly to the north, being 121 feet above the tracks at Martin's Ferry and still higher farther north in Jefferson county. In the southern part of the township the coal dips to the east at the rate of about 25 feet per mile.

Colerain Township. This township lies directly west of Pease and contains a large area of coal. Wheeling Creek crosses the southeastern part of the township in a deep valley along which the coal is everywhere above drainage. The coal is extensively mined.

Section 2 shows the coal in a mine of the Y. & O. Coal Company at Barton. The capacity of this mine was given at 1,000 tons per day.

SECTION 2

			Ft.	In.
7.	Breast coal,	Coal,	2	8½
		Bone coal,	0	¾
		Coal,	0	5
6.	Parting,			⅜
5.	Bearing in coal,			2½
4.	Parting,			¾
3.	Brick coal,		0	8
2.	Parting,		0	⅜
1.	Bottom coal,		1	2

Chemical composition and calorific value of Section 2:

Ultimate.		*Proximate.*	
Carbon	70.41	Moisture	3.79(a)
Hydrogen	5.14	Volatile Matter	36.37
Oxygen	10.20	Fixed carbon	50.84
Nitrogen	1.09	Ash	9.00
Sulphur	4.16		
Ash	9.00		
	100.00		100.00

Calorific value ....7,145 calories.

(a) Moisture in the air-dried sample about 3%.

This sample included parts 1, 2, 3, 6 and 7 of Section 2.

At Maynard in section 1, near the western border of the township, Professor Brown found the coal as follows:

		Ft.	In.
Roof coal, about		1	6
Draw slate (soapstone)		0	10
Breast coal	Bone coal	0	3
	Coal	1	6
Shale parting			
Bearing in coal		0	7
Shale parting			
Brick coal		1	6
Parting		0	
Bottom coal		1	0

Sections similar to the two just given can be duplicated in large number. The Roof coal ranges ordinarily from 12 to 18 inches in thickness and usually lies directly above the Draw slate. It is not mined. The structure of the main seam is characteristic, and can be duplicated in Pennsylvania, West Virginia and Maryland.

Flushing Township. This township forming the northwest corner of the county is completely underlain with coal in its eastern part. The central part has the coal in the high ridge between two branches of Stillwater while the area of coal in the western part is small and confined to the tops of the highest hills.

Section 2a shows the coal in the mine of the Kennon Coal & Mining Co. near Flushing.

SECTION 2 a

	Ft.	In.
7. Draw slate,	0	10
6. Bone coal, rejected,	0	2½
5. Breast coal,	1	7
4. Parting,	0	¼
3. Bearing in coal,	0	2
2. Parting,	0	¼
1. Brick and bottom coal,	2	5

A film of pyrites was observed 23 inches above the bottom but is not continuous. The Roof coal is reported to average 10 inches. The mine was opened about 1902.

Chemical analysis and calorific value of sample 2a:

Ultimate.		*Proximate.*	
Carbon	68.75	Moisture	4.23(a)
Hydrogen	5.14	Volatile Matter	36.34
Oxygen	11.64	Fixed carbon	50.22
Nitrogen	1.09	Ash	9.21
Sulphur	4.17		
Ash	9.21		
	100.00		100.00

Calorific value .... 7,003 calories.

(a) Moisture in the air-dried sample about 3%.

All was included in the sample except parts 6 and 7. Part 6 is rejected in the mine as well as in the sample. The sample was about 6 inches wide and one inch thick.

In the southwestern quarter of section 26 Professor Brown made the following measurement of the seam:

	Ft.	In.
Draw slate	0	10
Breast coal	1	10
Bearing in coal (slaty coal)	0	3
Brick coal	1	10
Shale or clay parting	0	1½
Bottom coal	1	0
Clay	1	2
Limestone, unmeasured.		

This seam shows some changes from that found farther east in the county. Thus the Bearing in coal which usually consists of coal with a subordinate quantity of shale or clay is replaced with a band of shaly coal. Further the parting between the lower two divisions of the seam is abnormally large.

Formerly a part of the slack from this mine was used for making coke.

In the northwest quarter of section 8, near the middie of the township, Professor Brown found the coal as follows:[1]

	Ft.	In.
Massive sandstone, unmeasured.		
Breast coal	0	10
Clay or shale parting	0	½
Bearing in coal	0	3
Shale parting	0	½
Brick and Bottom coal	2	5
Clay	2	6
Limestone, unmeasured.		

This section, as Professor Brown remarks, had the Roof coal, Draw slate and part of the Breast coal cut out by the sandstone ledge. "The eastern edge of this cut out is a short distance west of Rock Hill (section 32). The sandstone is well shown in the top of the ridge extending northwest from Rock Hill and seems to thicken to the west, reaching a thickness of from 20 to 25 feet."

The Ames limestone is well shown in the valley of Big Stillwater and tributaries. It ranges from 2 to 2½ feet in thickness and is highly fossiliferous.

Pultney Township. This township fronts on the Ohio River. Everywhere along this front the coal is above low water level and hence has been removed in the river valley. McMahon's Creek, which crosses the township from west to east, everywhere cuts through the coal, and the same is true of a tributary from the northwest. With these exceptions the township is underlain with the seam, save the very small areas from which the coal has already been mined.

The following interesting section measured by Mr. J. E. Hyde on the north side of McMahon's Creek about one mile west of Bellaire, shows the strata above the Pittsburg coal:

[1] Vol. VI., p. 611.

	Ft.	In.
Gray calcareous shales	14	0
Gray limestone, fine grained	1	0
Gray shales	3	0
Limestone and limy shales full of minute crustacean remains	1	6
Gray argillaceous shales	3	3
Meigs Creek Coal	5	0
Dark gray sandy shales	0	7
Sandy micaceous clay	0	7
Sandy micaceous shale	0	3
Sandstone, varies much	7	0
Parting of black shale	0	
Clay shale	0	6
Sandstone, quarried	16	6
Coal	0	4
Fire Clay	0	5
Coal	1	3
Limestone with layers of shale near top	6	10
Calcareous shales	2	3
Light gray limestone	6	6
Gray shale, argillaceous	1	10
Limestone	2	9
Shales	2	6
Shales and limestone, the latter thin-bedded	2	4
Clay shale	1	10
Limestone with shaly layers	4	0
Gray argillaceous shale	3	9
Pomeroy or Redstone coal	1	3
Gray argillaceous shale	0	9
Hard gray amorphous limestone with numerous minute fossils	2	0
Gray shale	0	4
Limestone, hard gray amorphous, with numerous minute fossils	1	0
Gray calcareous shale, with some minute fossils	2	3
Limestone, hard gray, amorphous with some fossils	2	0
Shales, hard with some lime and fossils	2	6
Unseen	12	6

Top of Pittsburg coal.

This section shows the intervals between the Pittsburg and Pomeroy or Redstone coals to be 23 feet and between the Pittsburg and Meigs Creek coals 86 feet. These intervals are fairly regular and may be traced southwest to Lawrence county, though ordinarily one of the three coal seams is very thin or wanting. The limestone recorded in this section between the Pittsburg and Pomeroy coal is persistent, having been found as far southwest as Pomeroy. In that part of the state, however, the limestone is much thinner than that shown in the section.

Section 3 shows the Pittsburg coal as found in the mine of the Empire Coal Mining Company one mile south of Bellaire.

No measurement of the Roof coal was made but it is reported from

6 to 18 inches thick and separated from the Breast coal by from one to two and one-half feet of shale. Occasionally, however, the Roof coal is said to rest directly on the Breast coal. It is not mined.

SECTION 3

	Ft.	In.
9. Draw slate,	1	0
8. Breast coal,	2	1
7. Pyrites,	0	⅜
6. Bearing in coal,	0	3
5. Shale and pyrites,	0	½
4. Brick coal, containing 6 very thin shale partings,	1	5
3. Shale and pyrites,	0	1
2. Bottom coal,	0	10
1. Shale,		

When this mine was visited (July, 1907) its capacity was 1,000 tons per day but this was soon to be doubled. The coal is shipped by river to various places and by rail to Indiana and northwest to the Great Lakes. Considerable of the output is used by the Pennsylvania Railroad and some finds a local market in Bellaire.

Chemical analysis and calorific value of sample 3:

Ultimate.		*Proximate.*	
Carbon	72.06	Moisture	3.51(a)
Hydrogen	5.45	Volatile Matter	38.65
Oxygen	10.70	Fixed carbon	50.98
Nitrogen	1.17	Ash	6.86
Sulphur	3.76		
Ash	6.86		
	100.00		100.00

Calorific value ....7,325 calories.

(a) Moisture in the air-dried sample about 3%.

In the sample all of the section was included except parts 1, 3, 5, 7 and 9. The sample was 6 inches wide and 3 inches thick. The face of the coal from which the sample was cut was rather loose owing

to shooting. This made it rather difficult to keep the section of uniform width. Nevertheless, the sample is believed to be fair.

Section 4 was measured in Neff Mine No. 2 in section 13, on the western side of the township.

SECTION 4

	Ft.	In.
9. Draw slate,	0	10
8. Bone coal, marketed,	0	1½
7. Breast coal, contains 4 pyrites streaks,	2	1½
6. Shale parting,	0	¼
5. Coal, including a pyrites band near middle,	0	2
4. Shale parting,	0	1
3. Brick coal, including 2 thin pyrites lenses,	1	5
2. Pyrites parting,	0	1½
1. Bottom coal,	1	3

The Roof coal was reported to vary in thickness from 2 feet to a few inches, and was not mined. It was said to contain much pyrites.

This mine has been in operation about three years, and when visited was producing 350 tons per day.

Chemical composition and calorific value of Section 4:

Ultimate.		*Proximate.*	
Carbon	70.57	Moisture	3.80(a)
Hydrogen	5.23	Volatile Matter	37.18
Fixed carbon	9.78	Fixed carbon	50.07
Nitrogen	1.20	Ash	8.95
Sulphur	4 27		
Ash	8.95		
	100.00		100.00

Calorific value .... 7,103 calories.

(a) Moisture in the air-dried sample about 3%.

This sample included all parts of the section except 2. 4 and 9. These were rejected by the miner also.

The sample was cut in the side of a room which had been exposed

about two weeks, but before sampling 2 or 3 inches of the surface of the coal were first removed. The cross section of the sample measured 6x3½ inches.

Richland Township. The land of this township is high, forming a watershed between Wheeling and McMahon's Creeks. In the northern part of the township the seam is exposed along Wheeling Creek and to a small extent along its tributaries. In the southeastern part of the township the coal is shown in the valley of McMahon's Creek, the seam disappearing beneath the bed of this stream a short distance east of Glencoe. The coal is mined by shafting near this village and a section will be found in the discussion of Smith township. When found the coal is normal in thickness and structure. Manifestly this township contains a very large quantity of the Pittsburg coal.

Union Township. This township is underlain with the Pittsburg coal except along its western edge where the headwaters of Stillwater Creek have in part removed it.

The coal is mined for shipment by the Wheeling Valley Coal Company at Lafferty, in the northeastern part of the township where Section 5 was made.

SECTION 5

	Ft.	In.
10. Draw slate soapstone,	1	0
9. Impure coal, rejected,	0	2
8. Breast coal,	1	9
7. Parting,	0	¾
6. Bearing in coal,	0	2
5. Parting,	0	¼
4. Brick coal,	1	8½
3. Parting,	0	⅜
2. Bottom coal,	1	2
1. Clay, unmeasured,		

This mine was opened about a year ago, (1906.) It has a steel tipple and is modern in all respects. The capacity of the mine is about 2,800 tons per day.

Chemical analysis and calorific value of Section 5:

Ultimate.		*Proximate.*	
Carbon	68.24	Moisture	4.46(a)
Hydrogen	4.85	Volatile Matter	36.00
Oxygen	10.60	Fixed carbon	48.78
Nitrogen	1.10	Ash	10.76
Sulphur	4.45		
Ash	10.76		
	100.00		100.00

Calorific value ....6,903 calories.

(a) Moisture in the air-dried sample about 3%.

The sample included the entire section except parts 1, 5, 6, 7, 9 and 10.

Along the western side of the township the seam has been mined by the farmers at a number of places. Professor Brown reports the coal from 3 feet 9 inches to 4 feet thick with a thin parting near the middle, in section 36 in the northwestern corner of the township. This structure is similar to that found in the same seam to the southwest in Athens and Gallia counties.

Kirkwood Township. This lies west of Union township and contains the coal in the higher hills and ridges only. The coal is not mined for railroad shipment, but supplies a local demand among the farmers.

Section 6 was measured in the bank of F. W. McCartney, one-half mile west of Hendrysburg.

SECTION 6

	Ft.	In.
6. Roof coal, reported,	1	0
5. Draw slate, reported,	0	6
4. Impure coal,	0	3
3. Breast coal, with numerous pyrites and shale lenses,	1	2 ½
2. Shale, and pyrites,	0	1
1. Brick and bottom coal,	2	11

PLATE I. Exterior Works of the Wheeling Valley Coal Co. at Lafferty, Belmont Co. Steel Tipple, Endless Chain Hoist, Self-dump, Electric Lighting and Power.

Here also the coal is divided into two benches by a parting. The Bearing in coal has disappeared, its place being taken by a parting of shale and pyrites, and the Brick and Bottom coals form a single bed. The duplicate of this structure can be found in Athens and Gallia counties. The Roof coal is not mined but is reported the best in the seam.

Chemical composition and calorific value of Section 6:

Ultimate.		*Proximate.*	
Carbon	67.41	Moisture	3.75(a)
Hydrogen	5.09	Volatile Matter	37.99
Oxygen	10.79	Fixed carbon	47.42
Nitrogen	1.11	Ash	10.84
Sulphur	4.76		
Ash	10.84		
	100.00		100.00

Calorific value ....6,865 calories.

(a) Moisture in the air-dried sample about 3%.

Parts 1 and 3 were included in the sample, the remaining parts of the section being rejected by both miner and sampler. The sample was 5 inches wide and 2½ inches thick.

In the Lightell mine, section 29, in the northwest corner of the township, Professor Brown found the coal as follows:

	Ft.	In.
Massive sandstone	22	0
Black slate	0	1
Slaty coal, used	0	4
Breast coal	1	0
Shale and pyrites	0	1
Bearing in coal	0	3
Shale	0	¼
Brick coal	1	6
Shale	0	1
Bottom coal	1	2½
Clay	0	5
Limestone, unmeasured.		

This section lies nearer the western margin of the field than the preceding section and yet shows the normal structure of the seam. The structure of the seam is less steady along its western margin in this part of the state, and sometimes the usual divisions are wanting.

Wheeling Township. The Pittsburg or No. 8 coal underlies the whole of this township except along Wheeling Creek and tributaries where the coal has been removed by erosion. Near the middle of the township the seam disappears beneath the bed of Wheeling Creek.

Section 6a represents the coal in the mine of the Columbian Coal Company at Fairport.

The coal contains about the usual quantity of pyrites though no

SECTION 6a

		Ft.	In.
7. Draw slate, soapstone,			
6. Breast coal,	Coal,	1	½
	Smut rock,	0	⅜
	Coal,	0	8½
5. Smut rock,		0	⅛
4. Bearing in coal,		0	5¼
3. Smut rock,		0	⅛
2. Brick and bottom coal,	Coal,	0	1½
	Parting,	0	½
	Coal,	2	2
	Parting,	0	¼
	Coal,	0	6½
1. Clay, unmeasured,			

regular bands of it exist. The mine has a daily capacity reported at 1100 tons.

Chemical analysis and calorific value of Section 6a:

Ultimate.		*Proximate.*	
Carbon	68.17	Moisture	4.25(a)
Hydrogen	5.19	Volatile Matter	33.53
Oxygen	11.25	Fixed carbon	51.87
Nitrogen	1.09	Ash	10.35
Sulphur	3.95		
Ash	10.35		
	100.00		100.00

Calorific value ....6903 calories(b).

(a) Moisture in the air-dried sample about 3%.

(b) The ultimate analysis and calorific value here given was not obtained until several weeks after the preparation of the fine sample and laboratory experiments indicate that the sample had increased in weight by oxidation about 1½%. A calorific value about 100 calories higher than that given appears to represent more nearly the fresh sample.

In this sample parts 2 and 6 only of the section were included.

Professor Brown reports that the coal is normal along the eastern border of the township, ranging from five to five and one-half feet in thickness and having the customary partings.

In the northeastern quarter of section 26 Professor Brown found the coal as follows:[1]

[1] Vol. VI., p. 610.

		Ft.	In.
Roof coal, unmeasured.			
Draw slate		1	0
Breast coal	Coal	0	6
	Shale parting	0	1
	Coal	1	0
Shale			
Bearing in coal		0	6
Shale.			
Brick and Bottom coal		2	11
Clay		1	0
Limestone, unmeasured.			

Here the Breast coal is divided into two parts by a thin band of shale, while the Brick and Bottom coals are without the shale band that is so commonly found between them.

The Roof coal is nowhere reported prominent in the township. Probably its average thickness does not exceed one foot.

Smith Township. This township is competely underlain with the Pittsburg coal, the seam rising nowhere to the surface. The coal is mined in the northeast corner of the township near the village Glencoe, and a shaft has been sunk near Warnock station.

Section 7 was measured in Delora Mine, No. 1, about a quarter of a mile west of Glencoe. The mine belongs to the Highland Coal Company of Wheeling.

SECTION 7

			Ft.	In.
6.	Draw slate,		0	10
5.	Breast coal,	Coal with one pyrites band,	1	11
		Pyrites,	0	$1\frac{1}{4}$
		Coal,	0	3
4.	Pyrites parting,		0	1
3.	Bearing in coal,		0	3
2.	Pyrites parting,		0	1
1.	Brick and bottom coal,	Coal,	2	4
		Pyrites,	0	$\frac{1}{8}$
		Coal,	0	4
		Pyrites,	0	$\frac{1}{8}$
		Coal,	0	$3\frac{1}{2}$

This mine is located in the valley of McMahon's Creek, the coal lying 55 feet below the bed of that stream.

The bearing in is made in the middle member of the Brick and Bottom coals. This part was included in the sample. The lower 3½ inches and the pyrites just above are left in the mine and were not included in the sample.

The Roof coal is reported one foot thick and lies directly above the Draw slate. Above the Roof coal is a heavy bed of soapstone. The Draw slate falls if not supported and the weight of the soapstone above the Roof coal makes keeping the entries clear rather difficult.

The seam is quite uniform in thickness. About 4 inches are left in the floor, below the cut made by the machines. The pyrites layers are fairly steady and the thicker ones are rejected.

When visited the mine was producing 1,000 tons per day, but had produced as high as 1,200 tons. This township has thirty-six square miles of the Pittsburg coal, and thus far the area has been little more than touched.

Chemical analysis and calorific value of Section 7:

Ultimate.		*Proximate.*	
Carbon	71.49	Moisture	3.21(a)
Hydrogen	5.14	Volatile Matter	36.82
Oxygen	10.77	Fixed carbon	52.71
Nitrogen	1.06	Ash	7 26
Sulphur	4.28		
Ash	7.26		
	100.00		100.00

Calorific value ....7,297 calories.

(a) Moisture in the air-dried sample about 3%.

Since the lower two members of part 1 were left in the mine they were not included in the sample. Parts 2, 3 and 4, which were also rejected by the miners were omitted in sampling. The sample measured 5 by 3 inches and is considered very fair.

Mead Township. This township lies south of Pultney and fronts on the Ohio River. The coal has long been mined along this stream. At present the principal mine is in the southeast corner of the township, about a quarter of a mile above the mouth of Pipe Creek. The mine is owned by the Johnson Brothers of Bellaire, and the structure of the coal is shown in Section 8.

The upper part of the Breast coal contains a number of pyrites lenses, but these are less numerous below. The Breast coal is considered the best part of the seam.

The Brick and Bottom coal contained at the place of sampling 7 smut streaks, the thickest measuring one-fourth of an inch; also 3 bands of impure hard coal ranging from one-half to one inch in thickness.

SECTION 8

	Ft.	In.
6. Draw slate,	1	4
5. Breast coal,	2	3
4. Shale parting,	0	½
3. Bearing in coal,	0	4½
2. Shale parting,	0	½
1. Brick and bottom coal,	3	2

The Draw slate is said to contract occasionally to one inch. Above it is found a thin band of coal measuring from one to two inches, and above this two feet of shales succeeded in turn by two feet of Roof coal.

The coal lies at the level of the river bed and is reached in the mine by an incline. Mining is done by compressed air and haulage by electricity. The mine was opened about 1902 and ships from 100 to 350 tons daily.

Chemical analysis and calorific value of Section 8:

Ultimate.		*Proximate.*	
Carbon	72.95	Moisture	2.91(a)
Hydrogen	5.11	Volatile Matter	37.94
Oxygen	8.59	Fixed carbon	51.15
Nitrogen	1.04	Ash	8.00
Sulphur	4.31		
Ash	8.00		
	100.00		100.00

Calorific value ....7,340 calories.

(a) Moisture in the air-dried sample about 3%.

A lense of pyrites found in part 5 of the section was rejected in the

sample. Parts 2. 4 and 6 were also rejected. The sample measured 2 by 4 inches and was cut from a face only two days old.

Three diamond drill tests have been made in this township by Hon. Samuel L. Mooney, of Woodsfield, who has placed the records at the disposal of the survey. In the southeast quarter of section 2 the coal measured 5 feet 1 inch and in the northeast quarter of section 8, 5 feet 5 inches. In the former case the Roof coal measured only 3 inches, but in the latter it was found thicker but with several partings of shale or clay.

Below is a complete record of the well drilled at Vallonia in the northwest quarter of section 14:

	Ft.	In.
Surface	6	00
Limestone	0	06
Limestone and shale, mixed	0	09
Limy shale	0	06
Soft gray shale	1	00
Sandy shale	1	00
Sandstone, gray	6	06
Gray shale	5	03
Limestone	0	06
Gray shale	0	03
Limestone	1	03
Soft green shale	1	06
Fire clay	0	06
Dark shale	0	03
Sandstone, gray	10	00
Gray shale	1	06
Dark shale	0	03
Limestone	0	06
Hard dark limy shale	1	03
Limestone	1	04
Limy shale	0	03
Hard shale with lime nodules	1	04
Limestone	0	09
Limy shale	0	04
Limestone and shale, mixed	0	06
Limy shale	1	00
Limestone	0	06
Gray shale	0	06
Limestone	0	08
Gray shale	1	06
Dark limy shale	0	08
Green limy shale	0	08
Sandy shale	1	00
Limy shale	0	06
Limestone	1	03
Limy shale, hard	1	06
Limestone	0	04
Cement rock	1	09
Hard limy shale and limestone	1	06
Dark shale and limestone, mixed	0	08
Gray shale	0	06

	Ft.	In.
Limestone	2	03
Gray shale	1	03
Cement rock	3	06
Hard dark, limy shale	3	09
Green shale	3	00
Red shale	0	03
Hard green shale	1	00
Limestone	0	08
Hard gray shale	0	04
Hard limy shale	0	09
Cement rock	5	03
Hard green shale	0	09
Hard gray limy shale	0	06
Limestone and shale, mixed	1	00
Gray sandstone	2	02
Gray and sandy shale	1	06
Cement rock	4	00
Hard dark limy shale	1	09
Limestone and cement rock, mixed	3	00
Hard dark limy shale	0	09
Limestone and cement rock, mixed	1	09
Hard limy shale	2	00
Limestone	0	08
Hard dark limy shale	1	00
Cement rock	4	00
Hard dark limy shale	0	03
Limestone	2	09
Hard gray shale	0	05
Limestone mixed with shale	0	06
Limestone and cement rock, mixed	1	04
Hard green limy shale	0	05
Limestone	0	08
Green limy shale	1	00
Hard dark gray slate	1	04
Cement rock	2	08
Limestone	0	03
Hard limy shale	0	08
Limestone, gritty	1	06
Hard limy shale	0	06
Cement rock	2	00
Hard limy shale	0	06
Limy shale with little limestone	0	08
Cement rock	2	00
Gray slate	1	00
Between limestone and cement rock	3	06
Hard dark limy shale	1	06
Green limy shale	0	07
Hard dark gray shale	2	03
Hard dark limy shale	1	02
Limestone and shale, mixed	0	06
Limestone	0	09
Limy shale, hard	0	07
Limestone	0	05

	Ft.	In.
Hard limy shale	3	06
Limestone and shale, mixed	0	05
Fire clay	2	08
Slate, dark	0	02
Coal, Meigs Creek	3	09
Sandy fire clay	0	08
Hard limy shale	1	00
Limestone	0	06
Soft gray shale with lime nodules	2	07
Sandy shale	8	00
Gray slate	7	03
Brown slate	1	00
Coal	0	05
Band	0	03
Coal	0	09
Dark limy shale	0	06
Limestone	2	03
Cement rock	1	03
Hard limy shale	0	03
Limestone	3	06
Cement rock	4	03
Hard dark gray shale	0	03
Limestone	2	00
Gray shale	1	00
Limestone	4	00
Hard limy shale	0	04
Limestone	1	04
Hard shale and limestone, mixed	0	10
Hard gray shale	1	00
Limestone and shale, mixed	0	06
Limestone	1	10
Hard limy shale	0	09
Green shale with lime nodules	1	00
Fire clay	1	06
Black slate	0	03
Green and black slate, mixed	0	09
Soft clay shale	2	09
Gray shale	1	06
Sandy shale	1	06
Black shale	0	03
Hard dark limy shale	1	06
Blue limestone	2	00
Limestone, gray	2	06
Hard dark limy shale	0	06
Blue limy shale, hard	1	03
Limestone and shale, mixed	1	03
Hard limy shale	3	00
Limestone and shale, mixed	0	03
Hard limy shale	2	00
Limestone and shale, mixed	2	00
Hard limy shale	0	09
Fire clay	1	09
Hard limy shale	0	06

	Ft.	In.
Fire clay and dark shale, mixed	0	11
Black slate	0	04
Roof coal	1	00
Band	0	03
Roof coal	0	05
Band	1	11
Coal, Pittsburg	5	00
Dark fire clay	0	04
Hard limy shale	1	07

Interesting to note none of these tests shows the Pomeroy or Redstone coal. The Meigs Creek coal was found thin and unimportant in the first well, but in the second one it measured 4 feet 1 inch with a half inch parting of pyrites. In the third well, as shown above, this seam measured 3 feet 9 inches.

York Township. This township forms the southeastern corner of the county. It fronts on the Ohio River and the coal is said to lie in the bed of this stream. Interesting to report the seam rises above drainage along Captina Creek in sections 21 and 27, near the middle of the township where it has been mined to a small extent. This plainly indicates the presence of an arch or anticline. Elsewhere in the township the coal is under cover.

On the Dorsey farm, southwest quarter of section 14, Professor Brown made the following measurement of the coal:

	Ft.	In.
Roof coal, average	1	8
Draw slate, average	1	2
Breast coal	2	1
Shale and pyrites	0	1
Bearing in coal	0	6
Shale	0	1
Brick coal	1	7
Pyrites band	0	1
Bottom coal	0	10
Coal, thin band, not measured.		
Clay, unmeasured.		

The coal is reached by a shaft 25 feet deep, and the fuel is lifted by horse power.

Washington Township. The coal in this township is everywhere below drainage, and so far as can be judged the township is everywhere underlain with the seam.

The coal has long been mined near Armstrong's Mills in the northeastern part of the township. Section 9 was measured in the mine of the Captina Coal Company in the northwest quarter of section 10.

The Roof coal is reported to vary from 10 to 15 inches in thickness and lies directly above the Draw slate. It is unmined but makes a good roof.

SECTION 9

	Ft.	In.
9. Draw slate	0	10
8. Bone coal, rejected	0	3
7. Breast coal, with 3 thin partings	2	8
6. Shale	0	1
5. Bearing in coal	0	8½
4. Shale	0	⅜
3. Brick coal, containing several smut bands	1	8½
2. Shale	0	½
1. Bottom coal, with occasional pyrites lenses	1	1

When visited in July, 1907, the mine was shipping about 80 tons of coal daily to points along the Ohio River and Western Railroad. The coal is regular and quite hard except a part about 10 inches above the base where the undercutting is done. Eighteen inches of the upper part of the Breast coal is very hard and blocks of considerable size are frequently loaded.

Chemical analysis and calorific vaue of Section 9:

Ultimate.		*Proximate.*	
Carbon	69.76	Moisture	2.79(a)
Hydrogen	5.25	Volatile Matter	37.88
Oxygen	9.39	Fixed carbon	49.91
Nitrogen	1.09	Ash	9.42
Sulphur	5.09		
Ash	9.42		
	100.00		100.00

Calorific value ....7,215 calories.

(a) Moisture in the air-dried sample about 3%.

Parts 2, 4, 6, 8 and 9 of the section were excluded from the sample. Parts 8 and 9 are rejected by the miner also but parts 6 and 4 are in-

cluded with the marketable coal. The sample, which measured 6 by 2 inches, was cut from a face that had been exposed less than a week.

Below is the record of a test made by the diamond drill at Alledonia in the southeast corner of section 22. This record has been placed at the disposal of the survey by Hon. Samuel L. Mooney, of Woodsfield.

	Ft.	In.
Surface	10	06
Yellow shale	2	00
Limestone, buff	3	00
Lime and shale, mixed	2	06
Hard dark green shale, flinty	2	03
Limestone	2	00
Limestone and shale, mixed	1	00
Hard dark gray shale rock, flinty	4	09
Limestone (with little shale)	9	06
Hard dark gray shale	1	06
Brown shale, hard	1	00
Fire clay	0	08
Soft clay shale	0	04
Black slate	0	01
Coal, Meigs Creek or No. 9	2	08
Gray, shale	1	03
Limestone	0	06
Hard sandstone	1	03
Sandy shale	0	03
Hard gray sandstone	4	09
Greenish shale	2	06
Limestone and shale with fossils	0	06
Greenish shale	1	00
Gray sandy shale	4	06
Part sandy shale and dark slate	3	06
Black slate	0	02
Coal	1	09
Dark shale	0	08
Limestone with fossils	0	06
Hard sandy shale, dark (sample)	0	03
Limestone with fossils	8	11
Cement limestone	4	06
Greenish shale	1	00
Limestone (sample)	4	09
Limestone and shale, mixed	1	00
Limestone	1	03
Hard dark shale	0	09
Limestone and shale, mixed	0	09
Sandstone and shale, mixed	1	06
Greenish shale	2	00
Gray sandstone	1	09
Gray soapstone	2	00
Hard gray shale	1	03
Limestone	5	04
Greenish shale	0	06
Limestone nodules	0	03
Greenish shale	1	03

	Ft.	In.
Brown shale	0	08
Coal, Pomeroy or Redstone or No. 8a	0	04
Hard gray shale	1	03
Blue limestone	1	05
Dark shale	0	05
Blue limestone	1	00
Gray limestone	4	00
Gray shale	0	04
Limestone	3	04
Limestone and shale, mixed	2	04
Limestone (sample)	1	09
Gray shale	0	06
Gray shale with limestone nodules	3	09
Fire clay	2	00
Coal, slaty	0	03
Dark slate	0	03
Roof Coal (Pittsburg)	0	10
Band fire clay	0	10
Coal, Pittsburg or No. 8	5	06
Fire clay	0	02
Calcareous shale, dark gray	3	09
Limestone with shale, hard	0	11
Limestone and sandy shale, mixed	0	11
Gray sandstone with iron	0	08
Gray shale and lime, mixed	0	06

Not only does this record show the Pittsburg coal in good thickness but the position also of the Pomeroy or Redstone and the Meigs Creek seams.

Wayne Township. In this township the Pittsburg coal is nowhere above drainage; neither is it mined and hence information must rest on the disclosures of the diamond drill.

Below is a record made in the valley of Captina Creek in the southeastern quarter of section 10. For this information the survey is indebted to Hon. Samuel L. Mooney, of Woodsfield:

	Ft.	In.
Surface, place of Meigs Creek or No. 9 coal	8	00
Limestone	1	00
Fire clay	3	06
Gray shale	3	04
Sandy shale	1	06
Hard black limestone	0	01
Gray shale	2	06
Sandy shale	6	00
Soft gray shale	8	03
Black slate	0	04
Coal	0	03
Dark shale	0	09
Limestone	2	00
Black shale	0	05
Limestone	5	02

	Ft.	In.
Black shale	0	03
Limestone	1	02
Dark shale	0	07
Cement rock	2	04
Limestone	2	02
Shale and lime, mixed	4	06
Sandy shale	1	06
Soft limestone	1	00
Sandy shale	1	00
Gray soapstone	4	00
Limestone	3	04
Soapstone and lime nodules	3	00
Coal and black slate, Pomeroy or Redstone	1	03
Fire clay	1	00
Gray shale	3	02
Black shale	1	00
Limestone	5	06
Limestone and shale	2	00
Limestone	3	00
Lime, fire clay	2	00
Gray shale with limestone nodules	3	00
Greenish shale	1	06
Dark shale, carbonaceous	3	02
Roof coal (Pittsburg)	0	10
Fire clay, band	1	00
Coal, Pittsburg or No. 8	5	07
Fire clay	4	01

A test was made in the northwest quarter of section 23, but the result was not favorable, the coal being only 2 feet 5½ inches thick, and this divided into two parts by a thin layer of shale. Above the coal is found a massive sandstone which probably explains the thinness of the seam. This test started above the horizon of the Meigs Creek seam. From drillings in adjacent townships it appears that this cut out is local, or at any rate, does not extend over a wide area.

Goshen Township. The coal in this township is everywhere under cover except a very small area in the northwestern section, No. 36. According to Professor Brown, the seam is there from 4½ to 5 feet thick and normal in structure.

In the southeast quarter of section 31, southwest corner of the township, the diamond drill showed only 3 feet 4 inches of coal. Above the seam lies a massive sandstone which very probably is responsible for the meagerness of the coal. This test is only about two miles from the one in Wayne township which disclosed less than 3 feet of coal and is doubtless included in the same basin.

The next test to be recorded was made in the northwest quarter of section 1, that is in the southeast corner of the township. For this and the preceding information indebtedness is acknowledged to Hon. S. L. Mooney.

	Ft.	In.
Surface	8	06
Yellow shale	1	00
Limestone	6	03
Green shale	2	00
Limestone	0	05
Green shale	0	03
Limestone with thin streaks of shale	4	06
Shale and sandy shale, mixed	1	06
Hard limy shale	1	00
Limestone	0	03
Greenish shale	0	06
Limestone	1	02
Green shale	0	06
Hard limy shale	0	08
Limestone	2	00
Hard limy shale	4	06
Greenish sandy shale	3	00
Between a limestone and blue core	5	06
Hard limy shale	0	09
Green shale	0	04
Limy shale, greenish	1	09
Hard limy shale	0	07
Limestone	1	05
Dark limy shale	1	00
Limestone	2	06
Hard dark limy shale	0	06
Limestone	6	00
Hard dark limy shale	0	06
Limestone	1	09
Green shale	0	10
Limestone	0	09
Green shale	0	09
Limestone	7	03
Limestone and shale, mixed	2	06
Blue core	0	09
Greenish limy shale	2	09
Limestone with little shale, mixed	1	03
Green shale	0	09
Gray shale	0	03
Blue core, or cement rock	3	00
Hard dark limy shale	0	09
Limestone mixed with shale	10	07
Limestone and dark shale, mixed	1	09
Coal, Meigs Creek or No. 9	3	02
Fire clay sandy	0	09
Cement rock, dark	2	00
Limestone	6	09
Greenish shale	5	06
Dark gray slate	3	08
Dark gray slate, very soft	1	03
Coal	1	06
Slate	0	01
Coal	1	04

	Ft.	In.
Black slate	0	03
Limy shale	0	09
Cement rock	1	02
Limestone with fossils	0	07
Cement rock	1	07
Limestone	0	07
Black shale	0	02
Limestone	3	00
Black shale and limestone, mixed	0	09
Dark shale with fossils	0	06
Limestone	0	06
Cement rock	3	00
Limestone	1	03
Greenish limy shale	0	05
Green shale	0	10
Limestone	3	06
Greenish shale	0	06
Limestone with dark streaks	4	06
Greenish sandstone	1	06
Soft green shale	2	06
Gray shale	2	02
Limestone	3	00
Limy shale, soft	1	09
Slate and bone coal, mixed, Pomeroy or Redstone or No. 8a.	0	05
Fire clay	1	06
Dark shale	0	02
Limestone	0	07
Limy shale	2	03
Blue limestone	3	03
Limy shale	0	06
Limestone	0	09
Limy shale and limestone, mixed	1	08
Limestone	4	00
Dark gray shale, hard	0	04
Limestone	3	00
Limy shale and limestone, mixed	1	09
Soft clay shale	1	00
Limestone	0	06
Hard gray shale	1	00
Limestone	0	08
Green shale with limestone nodules	1	00
Gray shale with limestone nodules	1	03
Fire clay with dark streaks	1	09
Roof clay	0	05
Band	0	11
Coal, Pittsburg or No. 8	5	01
Fire clay	0	02
Hard dark limy shale	2	06

Warren Township. The Pittsburg coal underlies a large part of this township. In the northern part the headwaters of Stillwater Creek cut through the seam, and along the western edge the coal is exposed in a

number of narrow valleys. Especially is this true in the southwestern corner where the headwaters of Leatherwood Creek have formed deep and relatively wide valleys.

Near Barnesville the seam has long been mined for local use and is known as the Lower Barnesville coal. The Meigs Creek seam which is mined in the same locality is known as the Upper Barnesville coal.

The coal is mined for rairoad shipment in the southwestern part of the township.

Section 10 was taken in the Media Mine of the Colburg Coal Company of Columbus, located in section 21.

SECTION 10

	Ft.	In.
8. Draw slate,	0	6
7. Black shale,	0	1 ¾
6. Impure coal, rejected,	0	2 ¾
5. Breast coal,	0	11
4. Shale,	0	1
3. Bearing in coal, impure,	0	5
2. Shale,	0	¼
1. Brick and bottom coal,	3	0

The coal contains quite a number of local partings of shale and pyrites. Those that are persistent are shown in the section. The coal is quite hard and yields a red ash on burning. Its thickness ranges ordinarily from 4 feet 6 inches to 5 feet 3 inches, the average being about 4 feet 8 inches. The Draw slate is taken down in the entries but not in the rooms. Shaly sandstone lies above the Draw slate, the whole making a good roof.

The sections show the Breast coal unusually thin and a corresponding increase in the other divisions of the seam. These changes probably result from the locality being near the margin of the great basin in which this seam was formed.

This mine was opened about 1904 and when visited in 1907 was producing about 200 tons per day. Mining was done by hand but preparations were being made to use machines. Much of the coal has been shipped to the Great Lakes.

Chemical analysis and calorific value of Section 10:

Ultimate.		*Proximate.*	
Carbon	67.64	Moisture	4.47(a)
Hydrogen	5.17	Volatile Matter	37.53
Oxygen	10.43	Fixed carbon	46.99
Nitrogen	1.08	Ash	11.01
Sulphur	4.67		
Ash	11.01		
	100.00		100.00

Calorific value ....6,875 calories.

(a) Moisture in the air-dried sample about 3%.

Parts 4, 6, 7 and 8 of the section were excluded in sampling. Likewise these parts are rejected by the miner. The sample measured 6½ by 3½ inches and was cut from a fresh face. Part 2 of the section was a little above the average in thickness and hence the percentage of ash may be a trifle high.

Somerset Township. This forms the southwestern corner of the county. Within the limits of the township the coal varies more than elsewhere in the county. On the west side of the township the coal thins, but is mined at a number of places. In section 31 in the southwestern corner of the township, however, the coal is represented by a black streak only or is entirely wanting. The same is true along the southern margin of section 25. In such places the horizon of the coal is sometimes determined by the limestones.

The coal is everywhere below drainage in the township except in the two western tiers of sections. It has long been mined at Temperanceville and vicinity and in the valley in the northwestern corner of the township.

Section 11 was taken in the Jeffries bank at Temperanceville.

SECTION 11

	Ft.	In.
4. Shale, unmeasured,		
3. Coal,	0	10
2. Shale and pyrites, rejected,	0	¾
1. Coal,	3	0

The upper part of the seam contained three very thin pyrites and shale partings, and substantially the same is true of the lower or principal part of the seam. Occasionally films of pyrites are found in vertical cracks in the coal.

This section is another illustration showing how the Pittsburg coal loses its well known structure along the western margin of the field in this part of the state. The structure is more like that of the Meigs Creek seam than of the Pittsburg, though it undoubtedly belongs to the latter.

The Jeffries mine supplies the village and surrounding farmers with fuel The coal is fairly hard and has a good roof. Below the coal the thick beds of limestone are found which are so common throughout the county. In fact these limestones are sometimes more persistent than the coal itself.

Chemical analysis and calorific value of Section 11:

Ultimate.		*Proximate.*	
Carbon	68.77	Moisture	4.08(a)(b)
Hydrogen	4.89	Volatile Matter	37.08
Oxygen	9.68	Fixed carbon	48.23
Nitrogen	1.10	Ash	10.61
Sulphur	4.95		
Ash	10.61		
	100.00		100.00

Calorific value ....6,931 calories.

(a) Sample slightly wet; Moisture possibly one-half per cent. high on this account.

(b) Moisture in the air dried sample about 3%.

Parts 2 and 4 of the section were rejected by both the miner and sampler. The sample measured 6 by 3½ inches, and was cut from a fresh surface.

Below is a record of a diamond drill test made at Somerton on the eastern side of the township:

	Ft.	In.
Surface	11	00
Soft yellow shale	1	06
Gray sandstone	61	02
Fire clay, limy	0	04
Slate and coal, Meigs Creek or No. 9	1	09
Limy shale, dark	0	05
Limestone	2	10
Hard dark shale	0	03
Limestone	0	06
Cement rock	1	06
Limestone	0	07
Limestone with fossils	0	06
Dark shale, hard	0	02
Limestone	3	00

	Ft.	In.
Black shale, hard	0	03
Limestone	1	03
Cement rock	3	06
Greenish sandy shale, with lime nodules	1	06
Clay shale	14	00
Greenish shale, sandy, with little lime	4	00
Lime or iron nodules	0	03
Gray sandy shale	5	00
Gray sandstone, place of Redstone coal	30	00
Dark gray shale with thin sandstone bands	2	09
Gray sandstone	1	03
Dark gray shale	0	03
Gray sandstone	2	03
Dark slate, with fossils	3	04
Slaty coal	0	03
Dark slate	2	11
Coal, Pittsburg or No. 8	4	07
Dark slate	0	02
Hard dark limy shale, fire clay	3	03
Shale with limestone nodules	0	09
Limestone	1	00

This shows 4 feet 7 inches of the Pittsburg seam, but less than two feet of the Meigs Creek while the Pomeroy or Redstone coal is wanting.

Another test was made in the northwest quarter of section 21 near the center of the township. This showed 4 feet 2 inches of the Pittsburg coal, but none of the Pomeroy or Meigs Creek seams. For these records the survey is indebted to Hon. S. L. Mooney of Woodsfield.

THE PITTSBURG COAL IN JEFFERSON COUNTY.

With the exception of Belmont county, Jefferson contains a larger quantity of the Pittsburg coal than any other county in Ohio. The coal rises rapidly to the north and west, so that north of the P. C. C. & St. L. R. R. the seam is found only in the tops of the highest ridges and hills.

While the coal has long been mined in this county it was not until the construction of the W. & L. E. R. R. about 15 years ago, which crosses the southern end of the county, that the production became large. Since that time other transportation lines have tapped the field making it one of the largest producers of fuel in the state. The following figures show the output of the county, nearly all of the coal being derived from the Pittsburg or No. 8 seam:[1]

Year	Short tons.
1897	751,848
1900	924,214
1901	1,322,305

[1] U. S. Geol. Survey.

1902	1,812,801
1903	2,479,211
1904	2,416,122
1905	3,269,376
1906	4,515,420

These figures show that the production has increased about six-fold in eight years. In 1905 Jefferson county ranked third in coal production in Ohio, being surpassed by Belmont and Athens counties only, but in 1906 the county took first place.

Thus far only a good start has been made in mining this seam, and the county will be a large producer for many years.

Mt. Pleasant Township. The Pittsburg coal underlies the whole of this township except the northern part where it has been eroded by Short Creek and Long Run. Along the latter stream in section 29, the coal disappears beneath the bed of the creek.

Dillonville, in the northeast corner of the township, is the principal mining point. In fact it is one of the best known mining centers in Eastern Ohio.

Section 12 was measured in Mine No. 2, of the Wheeling & Lake Erie Coal Mining Company at Dillonville.

The section of the Roof coal was taken in the main entry and according to the mine foreman, is abnormal, the usual succession above the Draw slate being 18 inches of coal, 3 feet of fire clay or rummel and above this limestone. The Roof coal is not mined.

This mine is reported to have been opened in 1893 and to have a daily capacity of 1,000 tons.

Chemical composition and calorific value of Section 12:

Ultimate.		*Proximate.*	
Carbon	69.56	Moisture	3.10(a)
Hydrogen	5.22	Volatile Matter	37.92
Oxygen	10.77	Fixed carbon	49.46
Nitrogen	1.10	Ash	9.52
Sulphur	3.83		
Ash	9.52		
	100.00		100.00

Calorific value ....7,153 calories.

(a) Moisture in the air-dried sample about 3%.

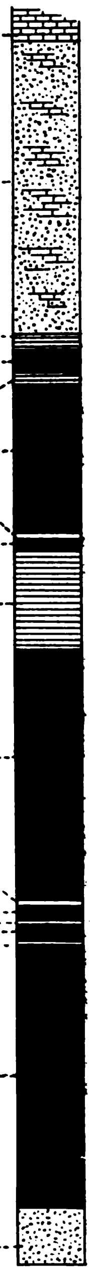
This sample includes parts 2 and 6 of the section, that is the Breast, Brick and Bottom coal. These are the only parts saved in mining.

The sample was taken in a new room under model conditions, and hence is unusually satisfactory. The width of the sample was 3½ inches and the depth 4 inches.

Smithfield Township. This township is twice the size of Mt.

SECTION 12

		Ft.	In.
11. Limestone, unmeasured,			
10. Clay, with some limestone,		3	0
9. Shales,		0	2
8. Roof coal,	Coal,	0	2 ½
	Shales,	0	1 ½
	Coal,	1	6
	Shales,	0	¾
	Coal,	0	1 ½
7. Draw slate, soapstone,		1	0
6. Breast coal,		2	6 ½
5. Parting, ⅝			
4. Bearing in coal,	Coal, 1 ⅜		
	Parting, ⅝		
	Coal, 2 ¼		
3. Parting, ⅜			
2. Brick and bottom coal,		2	8
1. Clay, reported thickness,		0	7



Pleasant and hence contains a larger area of the Pittsburg coal though in the latter the coal lies lower in the hills.

A splendid exposure of the Ames limestone is found in the bed of Short Creek at Adena. The formation is highly fossiliferous, several feet thick and lies about 175 feet below the Pittsburg coal.

Short Creek crosses the southwest corner of the township, exposing the coal along its banks. Several other streams have cut deep trenches through the coal making exposures numerous and mining comparatively easy. Most important of these streams is Piney Fork which crosses the township from the northwest to the southeast corner. The valleys of these streams are all narrow and hence the quantity of coal removed relatively small.

Section 13 was taken in the Crow Hollow Mine of the United States Coal Company, about two miles southeast of Smithfield.

SECTION 13

	Ft.	In.
7. Bone coal, not mined,		1
6. Breast coal,	2	1½
5. Parting,	0	⅜
4. Bearing in coal,	0	1⅝
3. Parting,	0	1
2. Brick and bottom coal,	2	2½
1. Clay, unmeasured,		

The Roof coal is reported to be uncertain, sometimes measuring one foot but usually less and occasionally wanting.

This mine has been in operation about five years and has a reported maximum daily capacity of 2,500 tons.

Chemical analysis and calorific value of Section 13:

Ultimate.		*Proximate.*	
Carbon	72.43	Moisture	4.96(a)
Hydrogen	5.37	Volatile Matter	34.51
Oxygen	12.67	Fixed carbon	54.08
Nitrogen	1.33	Ash	6.45
Sulphur	1.75		
Ash	6.45		
	100.00		100.00

Calorific value ....7,277 calories.

(a) Moisture in the air-dried sample about 3%.

The sample taken included parts 2 and 6 of the section. The bone

coal (part 7) is not mined, and parts 3, 4 and 5 are rejected by the miners.

Section 14 represents the coal in a mine of the United States Coal Company in the northwestern corner of the township.

SECTION 14

	Ft.	In.
7. Draw slate, soapstone,	0	9
6. Breast coal,	1	11
5. Parting,	0	1
4. Bearing in coal,	0	1
3. Parting,	0	¾
2. Brick and bottom coal,	2	2
1. Clay, unmeasured,		

No lenses of pyrites were found in this section but elsewhere in the mine they are quite common. The Roof coal was not seen but was reported to vary from 8 to 12 inches in thickness and to be inferior in quality.

This mine has a capacity of 1,600 tons per day and employs 350 men. The mine has four entries, but the coal is all handled at one tipple. Two electric motors are used to haul the coal.

Chemical analysis and calorific value of Section 14:

Ultimate.		*Proximate.*	
Carbon	71.34	Moisture	4.30(a)
Hydrogen	5.18	Volatile Matter	35.28
Oxygen	11.39	Fixed carbon	52.54
Nitrogen	1.20	Ash	7.88
Sulphur	3.01		
Ash	7.88		
	100.00		100.00

Calorific value ....7,144 calories.

(a) Moisture in the air-dried sample about 3%.

The sample included parts 2 and 6 of the above section, the rest

having been rejected by the miners as well as by the sampler. The sample taken was 6½ inches wide and 1½ inches deep.

In the northeast quarter of section 22 Professor Brown measured the following interesting section:[1]

		Ft.	In.
Shales, exposed		10	0
Pomeroy coal		2	1
Clay streak			
Limestone		2	0
Clay shale		11	0
Roof coal	Coal	2	6
	Shale	0	2
	Coal	0	8
Draw slate (clay or soapstone)		1	0
Black slate		0	1
Breast coal		2	4
Parting		0	½
Bearing in coal		0	1½
Parting		0	½
Brick coal		1	3
Shale parting with some pyrites		0	½
Bottom coal		1	0
Clay. Unmeasured.			
Limestone.			

The character of the roof in this mine is well shown by the following from Professor Brown's report: "This mine has been opened fifty-seven or fifty-eight years, and although in a very bad place and very poorly cared for, the roof, as far as examined, showed no signs of giving away. Many of the rooms are twenty-five to thirty feet span, and the posts have rotted away, yet the roof remains intact."

The sections of the coal already given can be duplicated in nearly every part of the township. Everywhere the structure of the seam shows the same features and approximately the same thickness. Hence no additional sections will be given.

Sections of the Roof coal are not easy to get because this part of the seam is rarely shown. In fact one has to hunt for places where this coal has fallen, in order to secure a measurement. The following additional thicknesses of this part of the seam may be reported:[2]

	Ft.	In.
South side, section 33	0	2-4
Southwest quarter, section 29	1	6
Northwest quarter, section 22	1	10

These figures indicate a marked variation in the thickness of this part of the seam. It is nowhere mined in the township at present, though it does not seem probable that coal operators will long allow from one to two feet of good coal to waste, especially when it can be

[1] Geol. Sur. of Ohio. Vol. VI., p. 601-2.

[2] Vol. VI., pp. 600-1.

easily saved. As is well known the Roof coal of this seam is now quite extensively mined in Pennsylvania.

Professor Brown found two blossoms of coal in section 28. One of these is 22 feet above the base of the Pittsburg seam, and is to be correlated with the Redstone coal of Pennsylvania and the Pomeroy coal of Southern Ohio. The higher blossom lies 101 feet above the same base and represents the Meigs Creek coal of Ohio and the Sewickley of Pennsylvania. As is elsewhere stated, this coal is not of workable thickness in Jefferson county. (Page 141).

In the southwestern quarter of section 15 Professor Brown found the Pomeroy or Redstone coal 12 inches thick, and 29 feet above the bottom of the Pittsburg seam. Not so much as a blossom of the Meigs Creek coal was found in this hill, though the conditions for exposure were favorable:[1]

From what has been said it is plain that Smithfield township contains a large and valuable deposit of the Pittsburg coal. The territory promises to be an important mining district for fifty years or more.

Warren Township. This township which lies east of Mt. Pleasant and the southern half of Smithfield contains a large body of the Pittsburg coal. The township is crossed by Short Creek which has cut a deep, though rather narrow valley, and fronts on the Ohio River. While the coal dips toward the river yet it is high in the hills on the river front owing to the depth of the valley.

In the mine of the Ohio and Pennsylvania Coal Company at Yorkville, the coal was found as shown in Section 15.

SECTION 15

	Ft.	In.
6. Breast coal,	2	7
5. Parting,	0	½
4. Bearing in coal,	0	1¼
3. Parting,	0	½
2. Brick and bottom coal,	2	5½
1. Clay, unmeasured,		

[1] Vol. VI, p. 601.

The Breast coal includes one inch of Bone coal which is sometimes rejected. The Draw slate, lying above the Breast coal, was reported to vary from 3 feet to nothing in thickness. In mining, the lower 2 to 3 inches of the Bottom coal are not removed owing to its reported inferiority.

While no pyrites was found in this section, an examination of coal mined showed considerable of this substance.

As the section shows the Brick and Bottom coal are not separated by a parting. The capacity of this mine was reported at 700 tons of run of mine and 400 tons of screened coal per day.

The following section of the Roof coal was made in an entry of this mine:

	Ft.	In.
Coal	0	5
Shale	0	9
Coal	0	8
Shale	0	7
Coal	0	10
Draw slate.		

Only six feet from this place the shales had disappeared leaving a bed of coal about 20 inches thick.

Chemical analysis and calorific value of Section 15:

Ultimate.		*Proximate.*	
Carbon	71.03	Moisture	3.13(a)
Hydrogen	5.38	Volatile Matter	37.88
Oxygen	10.09	Fixed carbon	50.77
Nitrogen	1.26	Ash	8.22
Sulphur	4.02		
Ash	8.22		
	100.00		100.00

Calorific value .... 7,233 calories.

(a) Moisture in the air-dried sample about 3%.

The sample taken was from parts 2 and 6, these being the only ones marketed, and was 6 inches wide and 2 inches deep.

Section 15a was measured in a mine of the Glenn's Run Coal Company.

At 5 and 11 inches above the bottom, two dirt streaks were noticed; one measured about one-fourth and the other three-eighths of an inch in thickness. Neither is thrown out in mining. The coal is not bright in appearance, but is quite free from pyrites.

SECTION 15a

	Ft.	In.
6. Breast coal,	2	4
5. Parting,	0	⅛
4. Bearing in coal,	0	1
3. Parting,	0	⅛
2. Brick and bottom coal,	2	1
1. Clay, unmeasured,		

Chemical analysis and calorific value of Section 15a:

Ultimate.		*Proximate.*	
Carbon	71.18	Moisture	4.57(a)
Hydrogen	5.06	Volatile Matter	32.40
Oxygen	11.89	Fixed carbon	54.03
Nitrogen	1.32	Ash	9.00
Sulphur	1.55		
Ash	9.00		
	100.00		100.00

Calorific value .... 7,105 calories.

(a) Moisture in the air-dried sample about 3%.

This sample included parts 2 and 6 of the section.

The following section of the coal was measured in the southwest quarter of section 28 on the bank of Little Short Creek:[1]

	Ft.	In.
Roof coal	2	2½
Draw slate (clay)	0	4
Breast coal	2	2
Clay parting	0	1
Bearing in coal	0	2
Black shale	0	½
Brick coal	1	3
Parting		
Bottom	1	2
Clay	0	4
Limestone, unmeasured.		

[1] Vol. VI, p. 603.

As has already been stated the coal is high in the hills along the river front. Thus at Yorkville the seam is 192 feet above the C. & P. Railroad tracks; at Tiltonville, one mile farther north, 212¼ feet; at Portland Station, less than two miles farther north, 272 feet, and in the southeast quarter of section 8, 297 feet.

Near Portland Station Professor Brown found the Ames limestone less than a foot thick and 197 feet below the Pittsburg coal. Farther north the limestone thickens and the interval between it and the coal increases, becoming 213 feet in section 8.

Wells Township. This township, lying north of Warren, contains a large area of the Pittsburg coal. The seam has suffered more from erosion than in any other township thus far considered. The valleys are numerous and deep, and the coal lies near the tops of the hills.

In the mine of Dewland Cox & Sons, at Brilliant, the coal was found as shown in Section 16.

SECTION 16

		Ft.	In.
6. Breast coal,	Coal,	1	7
	Parting,	0	¼
	Coal,	1	2
5. Parting,		0	2½
4. Bearing in coal,		0	2½
3. Parting,		0	¼
2. Brick and bottom coal,		2	3½
1. Clay, unmeasured,			

The abnormal thickness of the parting at the top of the Bearing in coal is local. A few feet away the thickness is less than a half inch.

This mine supplies the village Brilliant and the surrounding country with fuel. Four miners are employed during the busy season.

Chemical analysis and calorific value of Section 16:

Ultimate.		*Proximate.*	
Carbon	68.01	Moisture	4.89(a)(b)
Hydrogen	5.03	Volatile Matter	33.10
Oxygen	11.29	Fixed carbon	51.55
Nitrogen	1.12	Ash	10.46
Sulphur	4.09		
Ash	10.46		
	100.00		100.00

Calorific value .... 6,953 calories.

(a) Sample slightly wet. Moisture possibly one per cent high on this account.

(b) Moisture in the air-dried sample about 3%.

This section included parts 2 and 6. The mine had much water so that sampling cloth and sample were somewhat wet.

The coal rises rapidly to the north, being 343 feet above the C. & P. Railroad track at Brilliant. At this village the Ames limestone is five feet thick and lies 238 feet below the Pittsburg coal:[1]

Wayne Township. This township contains quite an area of coal near the tops of the high hills and ridges south of the P. C. C. & St. L. Railroad.[2]

Section 17 was taken in the McFadden mine of the Wayne Coal Company.

All the seam below the Draw slate is mined and shipped, the partings being too thin to be sorted out. Occasional lenses of pyrites are found and rejected.

Practically the entire output of this mine is shipped to Dennison and used in the yards of the Pennsylvania railroad.

The coal is reported to vary in thickness from 4 feet 2 inches to 4 feet 10 inches and to be similar in structure to the same seam farther south. Perhaps the seam contains more pyrite than is found in the townships to the south.

Chemical analysis and calorific value of Section 17:

Ultimate.		*Proximate.*	
Carbon	70.68	Moisture	5.05(a)
Hydrogen	5.32	Volatile Matter	35.88
Oxygen	12.19	Fixed carbon	51.12
Nitrogen	1.25	Ash	7.95
Sulphur	2.61		
Ash	7.95		
	100.00		100.00

Calorific value .... 7,147 calories.

(a) Moisture in the air-dried sample about 3%.

[1] Data on this township compiled from Prof. Brown's report. Vol. VI, pp. 599-600.

[2] Data compiled from Prof. Brown's report. Vol. VI, p. 597.

SECTION 17

		Ft.	In.
8. Roof coal, reported thickness,		0	10
7. Draw slate,		0	10
6. Breast coal,	Coal,	1	2
	Shale,	0	1/8
	Coal,	0	1
	Shale,	0	1/8
	Coal,	0	3
5. Bearing in coal, coal and shale,		0	1 1/2
4. Brick coal,		0	6
3. Coal with 1/2 inch of shale,		0	2 1/2
2. Bottom coal,		1	10
1. Clay, unmeasured,			

With the exception of parts 1, 7 and 8, the entire section was included in the sample, since all except these parts are marketed. The mine was very wet and in consequence the sample was taken in an entry. The sample was 6 inches wide and 2 inches thick.

Other Townships. Small areas of the Pittsburg coal are found in Island Creek, Cross Creek, Steubenville, Salem, Springfield, Ross and Knox Townships. In each of these the area of coal is small, and of importance only as a local supply. The seam possesses the same structural features that are found in the southern part of the county, though the coal is usually thinner, and, because of its poorer covering, more weathered.

THE PITTSBURG COAL IN HARRISON COUNTY.

The western margin of the Pittsburg coal underlies the higher parts of the eastern portion of Harrison county, being found in nine townships. The seam once formed a continuous stratum over this area, that which remains being the portion which has escaped stream erosion.

Until very recently the coal was mined for local use only, for which it has had a steady demand for perhaps three quarters of a century. Quite recently two or three mines for railroad shipment have been opened, and work will progress more rapidly in the future.

Southward the seam extends in Belmont county and eastward into Jefferson, in both of which it is extensively mined. A few small outliers of the coal are found in the hills of Carroll county to the north.

Short Creek Township. The coal in this township has been divided into three strips by two streams, Short Creek and Little Short Creek. The southernmost of these three strips, comprising as it does two rows of sections extending east and west across the township, is by far the largest. The coal has not been mined in this strip except along the north side where the seam outcrops in the deep valley of Little Short Creek. Here a number of country banks have long existed. Quite recently a mine for railroad shipment has been opened in the northeast corner of the township.

Section 18 was taken in a mine on the S. P. Dunlap farm in the northwestern part of the township.

SECTION 18

	Ft.	In.
7. Roof coal, reported,	2	0
6. Draw slate, soapstone, reported,	1	2
5. Breast coal,	2	1
4. Parting,	0	½
3. Bearing in coal,	0	2½
2. Parting,	0	¾
1. Brick and bottom coal,	1	10½

This mine supplies a local demand among farmers. It is worked regularly in winter but only an occasional day in summer.

Chemical analysis and calorific value of Section 18:

Ultimate.		*Proximate.*	
Carbon	70.49	Moisture	6.54(a)(b)
Hydrogen	5.70	Volatile Matter	35.48
Oxygen	13.66	Fixed carbon	51.24
Nitrogen	1.22	Ash	6.74
Sulphur	2.19		
Ash	6.74		
	100.00		100.00

Calorific value ....7,061 **calories.**

(a) Sample wet. Moisture approximately 2% high on this account.
(b) Moisture in the air-dried sample about 3%.

Section 19 was measured in the mine of The Adena Mining Company near Adena in the northeastern part of the township.

SECTION 19

		Ft.	In.
11. Roof coal,	Coal,	1	0
	Parting,	0	¼
	Coal,	0	½
	Parting,	0	¼
	Coal,	0	¼
10. Draw slate,	clay,	0	10
9. Bone coal, not mined,		0	1½
8. Breast coal,		2	5½
7. Parting,		0	½
6. Bearing in coal,		0	2
5. Parting,		0	½
4. Brick coal,		1	½
3. Pyrites layer,		0	1¼
2. Bottom coal,		0	11½
1. Clay, unmeasured,			

The layer of pyrites shown in this section is quite **persistent though not always present.** The daily capacity of the mine is **about 600 tons.**

Chemical analysis and calorific value of Section 19:

Ultimate.		*Proximate.*	
Carbon	71.20	Moisture	4.18
Hydrogen	5.36	Volatile Matter	36.95
Oxygen	11.13	Fixed carbon	50.65
Nitrogen	1.26	Ash	8.22
Sulphur	2.83		
Ash	8.22		
	100.00		100.00

Calorific value ....7,160 calories.

(a) Moisture in the air-dried sample about 3%.

This sample included parts 2, 4 and 8 of the section. Part 9 is not mined and parts 5, 6 and 7 are rejected by the miners.

Green Township. The Pittsburg seam in this township consists of a number of long narrow strips lying near the summit of high ridges. It has long been mined in a small way for local use, at a number of places, and within the past few years has been worked more extensively. Near the station Ginther, the following section was measured in the mine of the Pittsburg Block Coal Company:

	Ft.	In.
Roof coal, not mined	0	8
Draw slate (Soapstone)	1	0
Top or Breast coal	2	0
Shale and coal	0	2
Brick coal	1	1
Shale parting	0	¼
Bottom coal	1	2
Soapstone	0	4
Limestone, unmeasured.		

The thin band of coal and shale lying between the Top or Breast and the Brick coal represents the Bearing in seam.

German Township. This township, situated in the extreme northeast corner of the county, contains even less coal than is found in Green township. In fact the seam is present in only the highest hills. The following section of the coal was measured near the village of Jefferson, the altitude of the mine being about 1,237 feet:

	Ft.	In.
Shale, unmeasured.		
Bone coal. Not mined	0	2
Top or Breast coal	2	0
Shale and coal	0	3
Brick coal	0	9½
Shale parting	0	¼
Bottom coal	1	1
Fire clay	0	4
Limestone, unmeasured.		

Doubtless the three inches of coal and shale lying between the Top and Brick coals represent the Bearing in seam so well shown along the Ohio River and in Pennsylvania and West Virginia.

Rumley Township. This township, which lies west of German, contains very little of the Pittsburg coal, and the greater part of that lies in the hill-tops in the northeast corner of the township.

Archer Township. Two high and narrow ridges cross this township from the northwest to the southeast. These contain a small quantity of the coal under consideration. It is mined in a small way at a number of places, but can never be a large source of fuel. A small arm of the seam extends westward into Archer Township.

Cadiz Township. This township, situated on the divide between Stillwater and Short Creeks, contains a large quantity of coal, though it is confined to the high ridges. The seam has long been worked, especially in the vicinity of Cadiz.

Section 20 was measured in the mine of the Glover Coal Company at Cadiz.

SECTION 20

		Ft.	In.
9. Shales, unmeasured,			
8. Breast coal,	Coal,	0	7
	Pyrites layer, often wanting,	0	3/8
	Coal,	1	6
7. Shale,			
6. Bearing in coal,		0	2
5. Shale,			
4. Brick coal,		1	3
3. Shale,		0	1/4
2. Bottom coal,		1	1
1. Fire clay, reported thickness,		0	6

Pyrites concretions are found in the Brick coal. These sometimes become 3 or 4 inches thick and 2 feet in diameter. The coal is sold almost exclusively in the neighborhood but occasionally a carload is shipped.

Chemical analysis and calorific value of Section 20:

Ultimate.		*Proximate.*	
Carbon	67.70	Moisture	3.83(a)
Hydrogen	5.09	Volatile Matter	36.70
Oxygen	10.68	Fixed carbon	48.59
Nitrogen	1.27	Ash	10.88
Sulphur	4.38		
Ash	10.88		
	100.00		100.00

Calorific value .... 6,864 calories.

(a) Moisture in the air-dried sample about 3%.

Parts 1, 5, 6, 7 and 9 of the above section were rejected in sampling. The sample taken was 4 inches wide and 2 inches deep.

Athens Township. This contains in proportion to its size, a larger acreage of the Pittsburg coal than any other township in the county. In the southeastern part of the township the coal is below drainage and so is not mined. In the western part of the township, a number of farmers work the seam, and it is there the main reliance for fuel.

Section 21 was taken on the John Edwards farm, northeast quarter of section 1.

SECTION 21

	Ft.	In.
Roof coal,	0	10
7. Draw slate, soapstone,	0	10
6. Breast coal,	2	0
5. Bearing in coal. (coal and shale)	0	2
4. Brick coal,	1	3
3. Shale,	0	¼
2. Bottom coal,	1	½
1. Clay, unmeasured,		

The top coal is not mined and was not included in sample. In

mining the Brick coal is undercut, and the Bottom coal shot. Later the Breast coal is knocked down.

Chemical analysis and calorific value of Section 21:

Ultimate.		*Proximate.*	
Carbon	72.22	Moisture	5.98(a)
Hydrogen	5.44	Volatile Matter	34.35
Oxygen	13.71	Fixed carbon	53.70
Nitrogen	1.31	Ash	5.97
Sulphur	1.35		
Ash	5.97		
	100.00		100.00

Calorific value ....7,202 calories.

(a) Moisture in the air-dried sample about 3%.

The sample included parts 2, 3, 4 and 6 of the section, and was 4 inches wide and 2½ inches deep. On the Burney farm in section 12, the following measurement of the coal was made:

	Ft.	In.
Soapstone. Unmeasured.		
Roof coal, not mined	1	0
Soapstone	1	0
Top or Breast coal	1	3
Bearing in coal and shales	0	4
Brick and Bottom coals	3	6

The structure of the seam in this section shows a change over that of preceding sections, the Top or Breast coal thinning and the Brick and Bottom divisions thickening.

No extensive mining needs be expected in this township until it is penetrated by a railroad. It contains a large quantity of valuable fuel and will be ere long a busy mining center.

Moorefield Township. This township, lying west of Athens, contains a few thousand acres of coal lying in the highest ridges. It has long been mined by farmers, and will be their main reliance for fuel for many years.

Nottingham Township. This contains a few small outliners of coal extending west from Cadiz township and north from Moorfield. It is mined by farmers, but can never have more than a local value.

THE PITTSBURG COAL IN GUERNSEY COUNTY.

From Belmont county the Pittsburg coal extends west into Guernsey. However, it is found only in the higher ridges and hills and the area is small. Nowhere is it mined for railroad shipment.

Millwood Township. This township contains a larger area of the Pittsburg coal than any other township in the county. The seam is well shown in the ridges on the north and south sides of Leatherwood Creek

where it has long been mined for local use. The villages Quaker City and Salesville rely on these mines as do the surrounding farmers.

The Ames limestone is exposed in the valley at Quaker City, and was found by Professor Brown to be 190 feet below the coal. In the northeast quarter of section 20, near this village, Professor Brown found the coal as follows:[1]

	Ft.	In.
Shale, unmeasured.		
Shaly coal, rejected	0	3½
Coal	0	10
Shale and pyrites	0	¼
Coal	1	8
Clay	0	¾
Coal	1	4
Clay, unmeasured.		

The section shows the characteristic structure of the seam, as found farther east, wanting. The Bearing in coal is absent, and the Breast coal is abnormally thin. The shales above the coal are overlain with a heavy mass of sandstone. Occasionally the shales are wanting and then the sandstone rests directly on the coal.

Oxford Township. This lies north of Millwood township and contains a smaller area of coal. Near Fairview in the eastern part of the township Professor Brown reports the coal as follows:

	Ft.	In.
Shale, unmeasured.		
Coal	1	0
Shale or clay	0	4½
Coal	1	3
Parting, thin.		
Coal	1	0
Fire clay, unmeasured.		

Here the Bearing in coal is wanting, its place being taken by the 4½ inches of shales or clay. The coals below this bed represent the Brick and Bottom parts of the seam.

Londonderry Township. This township lies north of Oxford. The coal in question is found only in the tops of the highest hills and is of small value, even locally. The best deposit is found in sections 4, 5, 10 and 11 in the southeast corner of the township.

Other Townships. The Pittsburg coal is found in Spencer, Wills and Richland townships, but the quantity of coal is small. It is occasionally found in the tops of the highest hills, but can scarcely be rated as even a local source of fuel.

[1] Geol. Sur. of Ohio, Vol. VI, p. 623.

THE PITTSBURG COAL IN MUSKINGUM COUNTY.

The Pittsburg coal is restricted to the southeastern part of this county,—east of the Muskingum River and south of the Baltimore & Ohio Railroad, with the exception of a very small area in Union township.

The coal is thin, but very evenly developed over this area, with the exception of the southern part where it is wanting. It lies usually from 80 to 85 feet below the Meigs Creek coal, is generally about 30 inches thick, and is reported to be of better quality than the higher seam.

Blue Rock Township. This township lies directly north of Bloom township, Morgan county, and in the southern half, as in the northern half of Bloom, the Pittsburg coal is absent. In the ridge south of Kent's Creek near Keifer and east to the township line, the coal is present, but the blossom is rarely seen, owing to the slipping of the overlying shales. It has not been worked here and its thickness is unknown. In the extreme northeast corner of the township, in section 1, it was opened several years ago on the land of Edward Smith where it was reported 22 inches thick. It also occurs in the northern part of Meigs township to the east.

Salt Creek Township. The Pittsburg coal is found only in a narrow ridge in the extreme southeastern corner of this township but has been opened at a number of points. On the old J. W. Reasoner farm it was reported two feet thick. There it lies only 65 feet below the Meigs Creek coal, barometer measurement.

Rich Hill Township. In the southwestern part of this township, northeast quarter of section 31, the Pittsburg coal was formerly worked on the farm of Rachel Eckelberry where the following section was reported:

	Ft.	In.
Coal	0	6
White shale	0	6
Coal	1	10

In the southwestern corner of the township and along the western outcrop of the seam, this coal has been worked in years past at numerous points, and with the exception of the southwestern corner where it is a little thinner, is everywhere reported 30 inches thick, and is known as "the 30-inch vein." Very few of the banks are now in operation, however, as the farmers prefer the more easily worked but inferior Meigs Creek coal. The following section given by Brown shows the relation of this coal to the Meigs Creek and to the Ames limestone. It is from sections 21 and 22 near the center of this township.[1]

[1] Geol. Sur. of Ohio, Vol. V., p. 1071.

	Ft.	In.
Meigs Creek coal	4½	0
Not exposed	81	0
Pittsburg coal	0	30
Not exposed	151	0
Ames or Crinoidal limestone about	2	0

In the northeastern part, it is reported 30 inches thick but has been mined very little. In the eastern and southeastern part it is not worked and is probably thinner.

Union Township. The Pittsburg coal lies very near the top of the ridges in this township. To the north and west the seam is much thinner, and is probably not far from the northwestern limit of deposition. Over the central and southern parts it is reported about 30 inches thick. It was measured on the land of J. B. Morrow, one and one-half miles southeast of Norwich where it is 30 inches thick. A line of small outliers extends west from the main ridge at this place, and on one of these, on the farm of John McGee, one and one-half miles south of Norwich, the coal is said to be only 10 inches thick. It was not seen or reported north of the B. & O. R. R. tracks, although the ridge is high enough to hold it.

On the farm of Frank Wilson, section 12, two miles southwest of New Concord, the coal is reported as cannel, but it soon passes into soft coal as is shown on the opposite side of the ravine from the cannel exposure. On the farm of Samuel Noble, two and one-half miles south of New Concord, the coal is reported 46 inches thick, and all cannel except about one foot of soft coal at the top. This is probably the greatest thickness of this seam in Muskingum county but it is only a very local deposit, as it thins rapidly to 30 or 32 inches.

THE PITTSBURG COAL IN NOBLE COUNTY.

The coal in question is of very little value in this county. It is mined in one part only, namely a small area in the extreme northeastern corner. Throughout part of the county the seam is not represented by even a black streak.

The area of workable coal referred to in the above paragraph is in Beaver township. It lies north of Beaver Creek and east of a line drawn from Batesville to Quaker City. At present the seam is worked on the Deal farm in the southwest quarter of section 5 and on the Douglass farm in the southeast quarter of section 11. Both mines are small, supplying one or more farmers. Outside of this area the seam is of no importance in Noble county.

THE PITTSBURG COAL IN MONROE COUNTY.

This seam outcrops in the northwest corner of the county, especially in Malaga township. Farther west the coal thins. It is reported to have been mined many years ago in the vicinity of Calais in Seneca township, but the coal there is very thin and of little or no value.

Malaga Township. The coal is above drainage in the western third only of this township. It is mined on the George Neuhart farm in the southwest quarter of section 24. The proprietor reports the coal three feet thick with a sandstone roof and limestone below. Westward the coal thins rapidly and does not appear of value. To the east in section 24, the coal goes under cover.

In the next valley to the south the coal is of more value. It has long been mined in a small way in sections 28 and 29 on the Clause, Burkhart and Reimensnider farms. Everywhere the coal lies just above the limestone, which, in fact, is more persistent than the coal itself.

Below is a section of the coal on the Clause farm in section 28, as furnished by the proprietor:

		Ft.	In.
Roof Coal	Coal	0	6
	Shale	0	½
	Coal	0	6
	Shale	0	½
Clay		0	10
Coal		1	6
Clay		0	1
Coal		0	6
Clay		0	2
Coal		0	6
Clay		1	0
Limestone, unmeasured.			

On the Burkhart farm, adjoining the Clause, the coal was reported as follows:

	Ft.	In.
Shale, unmeasured.		
Coal with shale partings	2	0
Shale, hard	1	0
Coal	1	0
Shale, unmeasured.		

In section 33 in the southwest corner of the township, the coal has been stripped in the bed of the creek and was reported 18 inches thick.

Westward from the localities given, the coal thins rapidly and within a mile is too thin to work.

Summit Township. The Pittsburg coal outcrops in the valley at Burkhart, and is reported to have been stripped, having a thickness of 22 inches. There as elsewhere, the limestones below the coal are more conspicuous than the coal itself.

The Pittsburg coal is known to exist in the southern part of Belmont county almost to the county line. From this it is reasonable to conclude that the seam underlies the adjacent part of Monroe county. It is reported by oil drillers near Jerusalem along the Malaga-Sunbury township line, but is not reported in the oil field east of Woodsfield.

The coal has been reported on the basis of diamond drill tests at various places in the northeast corner of the township; in section 35 of Sunbury township, 5 feet; in section 28 of Switzerland township, 5 feet, 3 inches; in Section 32 of Salem township, 5 feet, 8 inches.

Several diamond drill tests have been made opposite Monroe county in or near the valley of the Ohio River in West Virginia.[1] In the southern part of Marshall county, near the village of Proctor, the coal measures 5 feet, 11 inches. This is opposite the northern part of Ohio township, Monroe county.

A test was made on the Higgs farm near Franklin Station, north of Proctor, and a thickness of 7 feet, 9 inches, found. Of this, 2 feet belongs to the Roof coal. This test was opposite Salem township, Monroe county. Other wells drilled in the same general territory gave similar results. The presence of the Pittsburg coal in large thickness in the valley of the Ohio certainly warrants the conclusion that the seam may be found in the adjacent part of Monroe county.

THE PITTSBURG COAL IN WASHINGTON COUNTY.

This seam is found in several townships of Washington county, but is nowhere an important source of fuel. It is at its best in Salem township, where it has long been mined in a very small way by farmers.

The seam is 2 feet or more in thickness in parts at least of the following townships,—Salem, Fearing, Liberty and Ludlow. Throughout this territory the coal is known as the "Limestone" or "Lower Salem," because of the limestones associated with it and from its being mined near the village, Salem, where a higher seam, the Meigs Creek is also worked.

As has already been stated this seam is not at present an important source of fuel in this county. In fact it is safe to say that it can never become a large producer. It is interesting geologically but not commercially.

The position of the seam is about 90 feet below the Meigs Creek coal which is the most important seam in Washington county.

In the eastern townships bordering the Ohio river, the Pittsburg coal is everywhere below drainage. Professor White states that it is from 135 to 150 feet below the river at Sistersville.[2]

[1] West Va. Geol. Sur. Vol. II, pp. 131-135.
[2] W. Va. Geol. Sur. Vol. I, p. 356.

The following record of Mehrley Well No. 10 opposite Sistersville, shows the relation of this coal to several important underlying formations.[1]

	Thickness of Formation.	Total Depth.
Unrecorded	175	175
Washington coal	3	178
Unrecorded	407	585
Pittsburg coal	5	590
Unrecorded	430	1,020
"Cow Run" sand	50	1,070
Unrecorded	55	1,125
Freeport sand	150	1,275
Unrecorded	365	1,640
Big Lime or Mountain limestone	97	1,737
Big Injun Sand	78	1,815

This shows an interval between the Pittsburg coal and the Big Injun sand of 1147 feet. Other wells drilled in the same locality[2] show that the Berea grit lies 500 feet below the top of the Big Injun sand, making the interval between the Pittsburg coal and Berea grit about 1650 feet. At Macksburg in the extreme northern part of the county this interval is only 1560, but at Flints Mills, nearly midway between Macksburg and Sistersville the interval is 1820 feet.[3] The latter figure is abnormal.

These intervals are helpful in an area like this where so often no well marked formation exists above drainage. On this basis the Pittsburg coal is about 250 feet below the valley of the Ohio at Marietta; and is everywhere under cover in that valley, above Marietta, except near Newport where the great Burning Springs anticlinal crosses the river bringing the Pittsburg coal and even lower formations above the level of the river.

Salem Township. The Pittsburg coal is found outcropping in all the deeper valleys of this township. About one mile northwest of Warner, on lot 38, the seam measures one foot five inches in thickness. It does not appear to be of workable thickness anywhere on the west side of Duck Creek in this township. Eastward and southward it thickens. The following section of this coal was measured on the J. W. Haas farm, about one-half mile north of Warner:

	Ft.	In.
Limestone. Unmeasured		
Shale	2	8
Coal	2	10

In the hills back of the village of Salem, Andrews found[4] the seam 2 feet 6 inches thick. It has been opened on several farms in

[1] Ibid. p. 356.
[2] Geol. Sur. of Ohio. Fourth Series. Bull. I. p. 196.
[3] Ibid. p. 190.
[4] Geol. Sur. of Ohio. Vol. II, p. 483.

this vicinity within the past few years, but the mines soon cave in and are abandoned. In the extreme northeastern corner of the township, on Crooked Run, Andrews found the seam 2 feet 8 inches thick.[1] Near Whipple along the southern line of the township the coal is partly cannel, and measures about 3 feet in thickness. It is mined in a small way near that village.

Obviously all that can be expected from the Pittsburg seam in Salem township is a supply for the residents, and that can be secured only at the expense of much labor.

Fearing Township. The Pittsburg coal outcrops in the northern part of this township along Duck Creek and Whipple Run. Near Whipple, as already stated, it measures about 3 feet in thickness, and has been mined to a small extent. According to Andrews the coal dips beneath the channel of Duck Creek on the Flanders farm, approximately three-quarters of a mile below Whipple.

Liberty Township. The Pittsburg coal was seen at two places in this township. It is reported to have been stripped in the bed of Paw-paw Creek in the southwest corner of section 33, and also in the bed of the creek at Fifteen P. O. in the northern part of section 7. The coal at this place is 700 feet above sea level. Practically the entire township is underlain with this seam, but it is thin and of little importance.

Ludlow Township. The Pittsburg coal is of even less importance in this township than in the one to the west, i. e., Liberty. No places were found where the coal is at present mined, or has been mined in recent years. Along Wingett's Run, near the western border of the township, Andrews reports the seam 2 feet 10 inches thick,[2] and the interval between this coal and the Meigs Creek, 94 feet. The coal lies at the level of the flood plain of the Little Muskingum River at Flint's Mills in section 22. The coal could not be measured, but Andrews reports it only 1 foot 2 inches in thickness. Farther east in this township the seam is below drainage. Obviously the Pittsburg coal can not become an important source of fuel in this territory.

Lawrence Township. No place was found in this township where the Pittsburg coal is of workable thickness. Usually it is represented by a black streak only and sometimes even that is wanting. The seam is above drainage along Cow Run, near the postoffice, but its thickness does not permit mining.

Newport Township. The horizon of the Pittsburg coal is elevated above drainage level by the great Burning Springs anticline which crosses the Ohio River about one mile west from Newport, but the seam is not of workable thickness.

From the center of this anticline or arch the seam dips both east and west, soon disappearing below the level of the Ohio River.

[1] Ibid. p. 485.

[2] Ibid. pp. 506-7.

THE PITTSBURG COAL IN MORGAN COUNTY.

I. East of the Muskingum River.

The Pittsburg coal is nowhere of importance in this area. It is at its best in Meigsville township where it ranges ordinarily from 15 to 24 inches in thickness. In places in this township two thin seams are found below the Meigs Creek coal, one 55 feet below this seam and varying from 12 to 20 inches in thickness; and the other about 80 feet below the Meigs Creek, and about 20 inches in thickness. The lower is the Pittsburg seam.[1] The higher of these two coals is the equivalent of the Redstone of Western Pennsylvania and the Pomeroy of Southern Ohio.

This coal is seen in the northwest corner of Meigsville township on Four Mile Run, where it measures 15 inches in thickness and lies 55 feet below the Meigs Creek coal. Three miles farther down this stream the Pittsburg coal is mined on land of C. C. Brown, and is reported to vary from 2 feet to 2 feet 6 inches in thickness. Its position here is approximately 80 feet below the Meigs Creek coal. On Dye's Fork of Meigs Creek, in the extreme northeast corner of this township, the Pittsburg seam measures about 2 feet in thickness and lies about 70 feet below the Meigs Creek.

In the southern and southeastern parts of Bristol township the Pittsburg coal measures only 18 inches in thickness, and is still thinner in the central and northern parts of the township. It is nowhere mined, and can never be a fuel of importance.

The seam is found also in southern Bloom township to the west of Bristol, where it is represented by 18 inches of coal and black shale. Elsewhere in this township the seam appears to be wanting.

The seam is occasionally noted in Malta township where its thickness corresponds with that in the other townships already mentioned.

Obviously this coal in the eastern part of Morgan county can never be of importance. It is little more than a shadow of the great seam found in Belmont and other counties.

II. The Pittsburg Coal West of the Muskingum River.

The Pittsburg coal, as a workable seam, in this part of Morgan county is limited to the two townships, Homer and Marion.

Homer Township. This township contains a larger quantity of the Pittsburg coal (here known as the Federal Creek) than is found in any other township in Morgan county. However, the coal lies high in the hills and hence is beneath only a fraction of the township. Further the coal is very unsteady in thickness, the result being that at least half

[1] Geol. Sur. of Ohio, Vol. V, p. 1066.

of the area cannot be worked. However, the coal has been mined on many farms and is an important local source of fuel.

The coal is at its best in the southeastern corner of the township where it is of workable thickness on both sides of Sharp's Fork. On the east bank of this stream the coal thins rapidly northward and has no value north of section 3. On the west bank the coal is more persistent and is workable as far north as the middle of the township, or nearly to the village Mountville.

Between Mountville and Bishopville the coal is found in good thickness on the ridges lying between Miners Fork and its western tributaries, these outliners being the remnants that have escaped stream erosion.

The coal has the structural features that are found farther south and southwest in Athens, Meigs and Gallia counties.

Section of the coal in the North Bank, southern part of section 1, near the Morgan-Athens county line:

	Ft.	In.
Bone coal	0	3
Soapstone	1	2
Coal	0	3
Pyrites streak	0	¼-½
Coal	0	7
Black streak	0	½
Coal	2	4½
Fire clay, unmeasured.		

In the entry to this bank the Top coal is not present, but it is found in another opening nearby and about 200 feet from the entrance. This illustrates very well the uncertain nature of the seam.

Section 22 was measured in the Waymer Bank, on the west side of Sharp's Fork in section 2, near Joy. Altitude of coal, 837 feet.

Chemical analysis and calorific value of Section 22:

Ultimate.		*Proximate.*	
Carbon	67.39	Moisture	6.87(a)(b)
Hydrogen	5.32	Volatile Matter	40.55
Oxygen	13.98	Fixed carbon	44.39
Nitrogen	0.90	Ash	8.19
Sulphur	4.22		
Ash	8.19		
	100.00		100.00

Calorific value .... 6,722 calories.

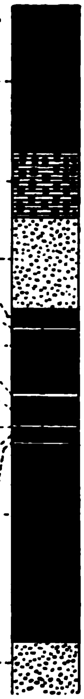
(a) Sample slightly wet. Moisture possibly 1% high on this account.

(b) Moisture in the air-dried sample about 3%.

The sample included the entire section except parts 1 and 3 and the bone coal comprising the base of part 4. The sample measured 6 by 1½ inches.

SECTION 22

		Ft.	In.
4. Upper bench,	Coal,	1	6
	Bone coal,	0	8
3. Soapstone,		0	11
2. Lower bench,	Coal,	0	2
	Parting,	0	⅛
	Coal,	0	7½
	Parting,	0	½
	Coal,	0	3
	Parting,	0	⅜
	Coal,	0	1½
	Parting,	0	⅜
	Coal,	2	0
1. Clay, unmeasured,			



Northward the coal thins rapidly, and in the northern part of section 3 is thin or wanting.

The Ames limestone is prominent in this locality, the interval between it and the coal being 170 feet. A short distance below Joy the limestone disappears beneath the valley.

Farther north along this stream the coal continues with both benches and is worked on the Berry farm in section 9. Northward it thins rapidly, soon losing its commercial value.

The following section was measured in the Lewis bank in the southeastern corner of section 15, near the center of the township.

	Ft.	In.
Soapstone	1	1
Coal	1	½
Shale parting, thin	0	0
Coal	2	11

Here the lower bench only is present. Southward the coal thins rapidly, and in a few hundred yards is not workable. In the Hogsett bank near the eastern margin of this section, however, both benches of the coal are found in good thickness.

The following measurement was made in the Steffy Bank in section 29 along the extreme western margin of this coal:[1]

[1] Geol. Sur. of Ohio. Vol. VI, p. 652.

		Ft.	In.
Upper bench	Coal	1	8
	Shale parting		
	Coal	2	0
Clay		1	0
Lower bench	Coal	0	4
	Shale parting		
	Coal	1	0
	Shale parting		
	Coal	1	11
	Shale parting		
	Coal	0	8

Marion Township. In this township the Pittsburg coal is of value in the southwestern corner only. The best deposits are found along Sharp's Fork and Opossum Run in sections 31 and 19. Probably the area of workable coal does not exceed four square miles. The coal is due in the northern part of the township, but is there represented by a black streak or is entirely wanting.

The following section of the coal was measured in the Edgerton Bank on Opossum Run near the Morgan-Athens county line:

		Ft.	In.
Shales, unmeasured.			
Upper bench	Coal	2	6
	Bone coal	1	0
	Coal	0	4
Soapstone		1	0
Lower bench.	Coal	3	7

In this mine the Upper bench is uneven and contains boulders of sandstone with pyrites. For this reason the bench is little used. The mine is worked throughout the year, supplying the neighboring farmers with fuel. Southward the Upper bench thickens and is important, but farther north along Opossum Run it is valueless.

THE PITTSBURG COAL IN ATHENS COUNTY.

The Pittsburg coal, here called the Federal Creek, is well developed in two townships, Ames and Berne and especially in the latter. It is found also in at least a half dozen other townships, but in them is of relatively small importance.

Here the structure of the seam forms a marked contrast with that found along the Ohio River in Belmont and Jefferson counties. The well known divisions such as Breast coal, Brick coal, etc., are wanting and the seam is divided into an Upper and Lower bench by a bed of clay or shale of varying thickness. From a study of the coal in this and in Gallia county and in the western part of Belmont it appears that the bed of shale or clay corresponds to the Bearing in coal with the

partings above and below, while the coal below the parting in question represents the Brick and Bottom coals, and the coal above the parting the Breast coal.

The thickness of the seam is much less uniform than farther east in the state and the coal is inferior in composition. Nevertheless it constitutes an important source of fuel, and in years to come will be better appreciated than at present.

Berne Township. The Pittsburg or Federal Creek coal is an important seam in this township. It outcrops in the valley of Federal Creek and its principal tributaries, Sharp's Fork, Opossum Run and Marietta Run. Probably the seam has been more extensively mined here than in any other township in Southern Ohio, and the production would be much greater if the shipping facilities were adequate.

At two places, Utley and Lathrop, the coal has been coked. On Federal Creek, just below Utley 125 ovens were built, but probably not more than 50 of these were in use at any one time. The coke is said to have found a ready market in Cleveland, Toledo, Chicago, Cincinnati and other places. Slack coal was used, the lump being thought too valuable for this purpose. Hence two kinds of cars were needed, one for coke and another for coal. The cars for coke are reported to have been secured without difficulty, but the supply for coal was insufficient and in consequence the works were closed about 1896. A few years later an attempt was made to reopen the coal mine, but the old difficulty again prevented success. This mine has employed 75 men and perhaps 15 more about the coke ovens. Mining was done by machinery, compressed air being the power.

The coke ovens at Lathrop number 50, but have not been used for years. However, they were being repaired during the summer of 1907 and probably by this time coke is being made. These ovens are the property of the Black Diamond Coal & Coke Company. The mine of this company was opened about 20 years ago, and during that time has been much hampered by a dearth of cars for shipment. Electric power is used, the mining being done by machinery. Section 23 was taken in this mine.

Chemical analysis and calorific value of Section 23:

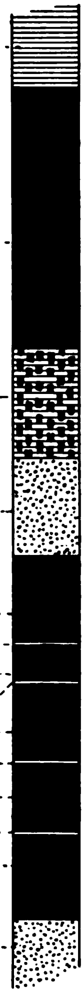
Ultimate.		*Proximate.*	
Carbon	67.55	Moisture	5.78(a)
Hydrogen	5.14	Volatile Matter	37.43
Oxygen	14.17	Fixed carbon	48.79
Nitrogen	0.95	Ash	8.00
Sulphur	4.19		
Ash	8.00		
	100.00		100.00

Calorific value ....6,833 calories.

(a) Moisture in the air-dried sample about 3%.

PLATE II. Abandoned Coke Ovens and Coal Tipple at Utley, Athens Co.

SECTION 23



		Ft.	In.
5. Shale, unmeasured,			
4. Upper bench.	Coal,	2	7
	Bone coal,	1	1
3. Soapstone,		1	0
2. Lower bench.	Coal,	0	10
	Parting,	0	$\frac{3}{8}$
	Coal,	0	4
	Parting,	0	$\frac{1}{4}$
	Coal,	0	9
	Parting,	0	$\frac{1}{4}$
	Coal,	0	8
	Parting,	0	$\frac{1}{4}$
	Coal,	0	10
1. Clay, unmeasured,			

This sample included everything shown in the section except parts 1, 3 and 5 and the lower part (Bone coal) of 4. The sample measured $5\frac{1}{4}$ by 1 inch.

Prominent in this mine and in other mines in this general locality are numerous "boulders." These are masses of sandstone or sandstone and pyrites, and vary much in size and shape. The largest may weigh a ton or more while the smallest are the size of pebbles. Sometimes the "boulders" are round, but more frequently they are decidedly oval. Not uncommonly they are nearly flat.

Generally the "boulders" are not found in equal abundance in all parts of the seam, and in the mine just described are rare in the Lower bench. Obviously the "boulders" are objectionable, since they diminish the quantity of coal and their handling is a dead loss.

The draw slate is uniform in thickness and except in being less of a shale and more of a clay, corresponds very well to the same formation in Belmont and adjoining counties.

Below is a section in the Schuler mine at Sharpsburg:

		Ft.	In.
Shale, unmeasured.			
Upper bench	Coal	4	0
	Bone coal	0	2
	Coal	0	4
Draw slate (clay)		1	0
Lower bench	Coal	2	10
	Pyrite streak	0	½
	Coal	0	8
Fire clay, unmeasured.			

The Upper bench here contains numerous "boulders" while the Lower bench is quite free from them. However, the Lower bench frequently contains thin shale or clay partings.

The coal is undercut by machines, but in other respects the methods are not so progressive. Ordinarily the miners number from 10 to 30, and shipment is entirely by rail. In other words this mine does not supply a local trade.

Lying about 25 feet above the coal is a thin stratum of limestone, and still higher a massive ledge of sandstone. The latter is prominent in this territory and appears to be the equivalent of the Pomeroy sandstone. The Pomeroy coal, however, which is due under the sandstone, was not found. It appears to be wholly absent in this part of Ohio.

In section 13 the limestone occurring 60 to 70 feet above the Pittsburg coal is more or less replaced by a sandstone containing large masses of white limestone which gives the rock a peculiar mottled appearance.

The following section, measured near the center of section 24, shows the strata from the Pittsburg coal up:

	Ft.	In.
Sandstone, slightly conglomeritic, weathers brown	38	0
Shales, red and gray	4	0
Shales, sandy	5	6
Clay, red	5	0
Sandstone, thin bedded	23	0
Clay, red with limestone nodules	17	6
Shale	20	6
Limestone and clay	8	0
Shale, dark	1	0
Limestone with interbedded clay	20	0
Not well shown, much limestone	11	0
Limestone, yellow, honeycombed	8	0
Sandstone, shaly	8	0
Shale, black streak		
Limestone interbedded with clay	60	0
Sandstone, Pomeroy	16	0
Shale	17	0
Coal, Pittsburg	8	0

The third important mine is at Broadwell in the southeastern part of the township, and is operated by the Federal Coal Company of Marietta, Ohio. Section 24 was taken in this mine.

SECTION 24

		Ft.	In.
4. Upper bench,	Coal,	1	3
	Bone coal,	0	3½
	Coal,	0	4
3. Soapstone,		1	0
2. Lower bench,	Coal,	0	6
	Parting,		
	Coal,	0	2
	Parting,	0	½
	Coal,	2	5
1. Clay, unmeasured,			

Some pyrites nodules are found in the coal, especially in the Lower bench. Where normal the roof is shale, even and strong. Often, however, the roof is irregular and composed of hard clay or shale, with smooth slickenside like surfaces.

Chemical analysis and calorific value of Section 24:

Ultimate.		*Proximate.*	
Carbon	66.61	Moisture	6.60(a)
Hydrogen	5.13	Volatile Matter	35.05
Oxygen	13.72	Fixed carbon	48.15
Nitrogen	0.93	Ash	10.20
Sulphur	3.41		
Ash	10.20		
	100.00		100.00

Calorific value .... 6,607 calories.

(a) Moisture in the air-dried sample about 3%.

In this sample part 2 only of the section is included. The sample measured 6 by 1½ inches and was cut from a fresh surface in a dry room.

Part 4 of the section was sampled separately. In this sample the

Bone coal was rejected, as it is also by the miners. This sample was wrapped in the sampling cloth and one hour and a half later was put in a can and sealed in the usual manner. Below is the analysis of this part of the seam:

Ultimate.		*Proximate.*	
Carbon	65.92	Moisture	4.51(a)
Hydrogen	5.10	Volatile Matter	38.24
Oxygen	11.62	Fixed carbon	45.76
Nitrogen	0.99	Ash	11.49
Sulphur	4.88		
Ash	11.49		
	100.00		100.00

Calorific value .... 6,636 calories.

(a) Moisture in the air-dried sample about 3%.

The coal is cut by machines but is hauled by mules and cable.

Other mines exist in the vicinity of Broadwell, especially along Marietta Run. One of these, the Grandstaff, supplies a large local demand among the farmers. Formerly there was a mine at Big Run but this has been abandoned several years because of inadequate shipping facilities.

From Broadwell the coal may be followed south into Rome township, where it goes under cover in section 19.

It is doubtful if the coal in good thickness extends in the hills far west of Broadwell. No mines are in operation on the west bank of Federal Creek above Broadwell, and the Upper bench of the coal is reported to be absent in most places in that locality. The township line just east of Amesville is regarded as the extreme western limit of workable coal on the south bank of Federal Creek.

Ames Township. The Pittsburg or Federal Creek coal is an important local source of fuel in this township. No shipments are made by rail. The coal is at its best in the northeastern part of the township between Linscott Run and Hyde Fork, but even there, as the sections given below show, the seam is inferior in thickness to the coal in Berne township. The coal west and southwest of this territory is thin and sometimes absent.

Section of coal measured in the Jones bank, southwest corner of section 5:

	Ft.	In.
Shales, unmeasured.		
Upper bench { Coal	0	1
Upper bench { Shale, dark	0	3
Draw slate, (clay)	1	0
Lower bench. Coal	3	6

This shows the Upper bench marked by a streak of coal. Sometimes this increases in thickness several inches, but does not become workable.

In the southeastern part of this section the coal measures less than 36 inches, but along Linscott Run, farther north, the coal improves. Thus in the Moses Ball mine in section 6 the Lower bench has 46 inches of coal, though the Upper bench measures only 4½ inches of good coal; but farther around the hill the Upper bench is present in full and the total thickness of the seam is there reported to be 8 feet.

The coal was found as follows in the Rice bank, section 11:[1]

	Ft.	In.
Coal	0	5
Clay	1	0
Coal	0	8
Shale streak	0	0
Coal	2	0
Shale streak	0	0
Coal	0	8

The interval between the Ames limestone and the Pittsburg coal in this section is only 125 feet, as shown by the aneroid barometer. This is less than at Joy, a few miles farther north where the interval measures 170 feet.

The following section was made near the center of section 35, along the extreme western outcrop of the Pittsburg coal:

	Ft.	In.
Clay with imbedded limestone	23	0
Shales	12	0
Pittsburg coal	1	0
Clay with imbedded limestone	13	0
Shales, sandy	20	0
Limestone	1	3

However, on the Sayres farm, in the southeast corner of section 36 the coal measures from 4 to 5 feet, and is mined for home use. Farther north in sections 30 and 36 the coal is also of workable thickness.

In section 23 the Meigs Creek coal is frequently seen. Its position is about 110 feet above the Pittsburg coal, which is from 20 to 30 feet greater than the corresponding interval to the northeast in Belmont county. On the Kasler farm the coal has been mined and is reported to be from 36 to 40 inches thick. Numerous other openings in the Meigs Creek coal have been made in this section, but no mine is now worked.

From what has been said it is clear that the Pittsburg coal in this township is very uncertain and of value in places only.

Athens Township. The Pittsburg, or No. 8, coal is limited to the tops of the highest hills in the eastern part of this township. Probably the workable coal does not exceed a few acres in area.

The following section was measured with an aneroid barometer on a

[1] Geol. Sur. of Ohio, Vol. VI, p. 651.

hill one mile southeast of Athens. It shows very well the various strata and gives approximately at least their thickness:

	Ft.	In.
Shaly sandstone, unmeasured		
Coal blossom, Pomeroy, No. 8a		
Limestone nodules and shales	20	0
Coal blossom, Pittsburg, No. 8		
Shales	5	0
Sandstone	35	0
Coal blossom		
White limestone	2	0
Shales	57	0
Bastard limestone	1	0
Shales	43	0
Ames limestone	1	8
Unseen, mostly shales	85	0
Cambridge limestone	2	0
Shales, unmeasured.		

The white limestone with the coal blossom above, is common in the southern part of Athens county. The coal blossom has a more extensive range, being common in Meigs county, but the limestone is there wanting. The coal is rarely more than 15 inches thick and is very slaty.

The Cambridge limestone is well shown along the Baltimore & Ohio railroad tracks in Athens, while the Ames limestone is found higher in the hill.

At Athens the shale near the horizon of the Ames limestone is utilized for the manufacture of brick by the Athens Brick Company. The following section was made in this pit:

	Ft.	In.
Sandstone	5	0
Shales	30	0
Ames limestone	1	4
Shales, blue and red	35	0

The Middle Kittanning coal is shafted on Sugar Creek in the northeastern part of the township, by the Sunday Creek Coal Company.

In section 1 near the head of the Middle Branch of Shade River, the shales overlying the Pittsburg coal contain much silicified wood, and many fine museum specimens have been taken from this locality.

Canaan Township. This township, which lies south of Ames, probably contains even less of the Pittsburg coal than does the latter. In fact throughout the greater part of this township the coal in question is entirely wanting or is represented by a black streak only. The workable coal is confined to a narrow strip about one mile wide extending across the southwestern corner of the township, with an outcrop along the valley of Long Run and the hills facing the Hocking River.

On the north side of the Hocking River the total area of workable coal is probably less than 500 acres lying in sections 34 and 35. The

coal farther north is reported to be less than 24 inches thick. To the east the coal thins rapidly and in places is represented by only a streak of clay. South of the Hocking River a trace of the Pomeroy or 8a coal lying about 20 feet above the Pittsburg is occasionally found.

Near the north edge of section 34 on the Mansfield farm much coal has been mined in former years. Both benches are reported with a total thickness of about 6 feet. The altitude of the coal here is 871 feet. The following section was taken on the same farm with an aneroid barometer:

	Ft.	In.
Shale, unmeasured.		
Coal Pittsburg No. 8	6	0
Unseen	12	0
Sandstone	50	0
Unseen	106	0
Ames limestone	1	6

The coal is said to be nearly worked out in section 33. In the Finsterwald bank the structure is as follows:[1]

		Ft.	In.
Upper bench	Coal	0	7
	Slate streak		
	Coal	2	1
	Bone coal	0	7
	Coal	0	5
Draw slate (clay)		0	10
Lower bench	Coal	0	6
	Slate streak		
	Coal	2	6

The following section was taken on the Sheridan farm in the northwest corner of section 25, where the coal has been stripped for the local market:

		Ft.	In.
Shale, unmeasured.			
Upper bench	Coal	2	2
	Bone coal	1	0
Draw slate		1	7
Lower bench	Coal	0	4
	Shale	0	$\frac{1}{4}$
	Coal	0	5
	Shale	0	$\frac{1}{4}$
	Coal	0	7
	Shale	0	1
	Coal	2	1
	Shale	0	10
Clay with limestone nodules		15	0
Sandstone		40+	

[1] Geol. Sur. of Ohio, Vol. VI, pp. 646-647.

The top coal is very irregular and contains many lenticular "boulders."

On the west side of Long Run the Upper bench of the coal is usually wanting and the Lower bench is often below the normal thickness.

At the head of Willow Creek near the Eastern margin of section 25 the coal is reported to be 30 inches thick. Farther east the coal thins rapidly.

The limestone ledge, the base of which lies about 65 feet above the Pittsburg coal, is persistent throughout the township and forms conspicuous bluffs in many places along the Hocking River. The slaty coal above the limestone is usually present.

The sandstone, the base of which is about 90 feet above the Ames limestone, attains an unusual thickness in the western part of the township, often extending up close to the Pittsburg coal. This sandstone is quite prominent in sections 28 and 34.

In the northwest corner of section 9 the Middle Kittanning coal is reached by a shaft recently put down by The Canaan Coal Company.

Rome Township. The Pittsburg coal horizon has been exposed by stream erosion in only three sections in this township, namely, 32, 33 and 18. Near the southeastern edge of section 32 the coal dips beneath the bed of Hocking River. In this territory the coal is represented by a dark streak only.

The Pittsburg coal rises above drainage on Federal Creek in section 18 near the mouth of Big Run. Here the coal was formerly mined.

At Kilvert, near the north edge of section 17 the coal has been mined by shafting, the depth being 40 feet.

The Meigs Creek coal is mined in several places along Big Run. The following section was taken in the A. V. Duffy bank near the west edge of section 6:

	Ft.	In.
Coal	2	1
Shale	1	8
Coal	0	5

The Federal Creek, or No. 8, coal has been reached by a shaft sunk by the Arcadia Coal Company on Two-mile Run near the southern edge of section 4, Decatur township, Washington county. The shaft has a depth of 117 feet and was sunk about the year 1897. A good thickness of coal is said to have been found, but the plant has long been quiet. The altitude of the coal there is 513 feet. At Sharpsburg 8¼ miles north, 20 degrees west, the Pittsburg coal has an altitude of 741 feet. Hence the dip per mile, between the two points in question is 27.8 feet.

The base of the following section, taken near the center of section 32, is about 65 feet above the Pittsburg coal horizon:

	Ft.	In.
Sandstone, thin bedded	15	0
Shale	5	0
Slaty coal	0	8
White limestone, interbedded with clay	30	0
Black streak	0	½
Clay with limestone nodules	5	0

The limestone ledge of the above section dips below the bed of the Hocking River near Stewart Station.

On Green Run near the township line south of Guysville, the coal above the limestone has been stripped, a thickness of from 8 to 15 inches being reported.

Alexander Township. The Pittsburg coal is very uncertain in this township. There is doubtless some workable coal in nearly every section where it outcrops but the thickness varies much and rapidly. In the northeastern corner of the township, in sections 5, 6 and 12, the coal is represented only by a black streak. In sections 10 and 11 considerable coal has been taken out in former years.

The Pittsburg coal is mined in the Bennet bank, northeast corner section 4, to supply the country market. The following section of the coal was furnished by a miner. It represents the Lower bench only, the Upper bench being absent.

	Ft.	In.
Shale, unmeasured.		
Soapstone	1	0
Coal	1	6
Shale	0	½-1
Coal	1	6
Pyrites	0	½-1
Coal	1	3
Fire clay, unmeasured.		

Several inches of coal are left in the roof to support the soapstone.

In the southeastern part of the township the coal is usually thin and has been worked in very few places. Considerable coal has been taken out in the high ridges of sections 9, 14, 15, 20 and 21.

The following section was taken on the road near the Bennet mine:

	Ft.	In.
Shale, unmeasured.		
Pomeroy coal, No. 8a	1	0
Shale with nodular limestone	21	6
Pittsburg coal No. 8	4	0
Shale	8	0
Sandstone, unmeasured.		

In section 26 the aneroid showed the interval between the Pittsburg coal and the Ames limestone to be 164 feet.

Lodi Township. It is probable that the Pittsburg coal is present in workable quantity over two-thirds of Lodi township. However, the Pittsburg horizon has been cut through only along the deeper valleys and hence the extent of the out-crop is rather limited. The seam is shown along the following streams: Willow Creek, sections 12 and 18; the Middle Branch of Shade River extending diagonally southeast across the township; Long Run, sections 19, 25, 26, 32 and 33.

On Willow Creek, near the northern edge of the township, the Pittsburg coal is wanting.

Along the Middle Branch of Shade River the Pittsburg, or No. 8, coal is workable from the southeast corner of section 29 to where it dips below the bed of the creek in the northwest corner of section 9.

At Judson P. O. section 17, the coal has been mined in a small way for many years, a thickness of four feet being reported. The altitude of the coal is 725 feet, and it is very near the level of the flood plain of Shade Creek. Farther down stream, the coal has been stripped in various places. Along this stream the coal is for the most part restricted to the Lower bench.

In describing Athens township mention was made (p 78) of a coal blossom, overlain by massive sandstone, which lies about 90 feet above the Ames limestone. In the southwest corner of section 36, Lodi township, this coal attains a thickness of 30 inches and has been mined on the Rogers farm. The altitude of the seam is there 755 feet. This seam is rarely more than a shale streak and has not been observed in workable quantity at any other place.

The structure of the Pittsburg coal in the Fulton bank on the eastern side of Long Run, section 30, is as follows:

		Ft.	In.
Shale, unmeasured.			
Upper bench	Coal	2	4
	Black slate	1	0
	Coal	0	4
Soapstone		1	0
Lower bench, Coal		2	4
Fire clay, unmeasured.			

The structure of the coal here is very similar to that of the Federal Creek region. Both benches are mined and the shale roof is strong.

Dover Township. The eastern part of this township contains numerous unusually high hills, some of which reach the horizon of the Pittsburg coal. However, the workable coal is limited to three small hills in the eastern part of section 6, where the seam attains a thickness of 4 feet.

The coal is due in the high ridges in sections 3, 4 and 9 but scarcely a black streak can be found. In section 9 a slaty coal, commonly occurring about 90 feet above the Ames limestone, has a thickness of over

5 feet, while about 50 yards away not even a black streak can be seen although the rocks are well exposed.

The massive sandstone immediately above this stratum is unusually thick, reaching up to the Pittsburg horizon.

Trimble Township. Sections 1 and 2 of this township contain a few hill tops where the Pittsburg coal is due but the seam is wanting.

The following section was taken at Tunnel No. 3, on the M. C. & C. R. R.:

	Ft.	In.
Sandstone, unmeasured.		
Shales	7	0
Shales, dark	8	0
Ames limestone	0	2
Black shales	3	10
Coal	1	0
Clay with nodular limestone	8	0
Shales, sandy	3	0
Sandstone	6	0

The coal is often thicker than shown in the above section and has been stripped by the farmers in many places.

THE PITTSBURG COAL IN MEIGS COUNTY.

The seam is important in two townships only in this county, namely Scipio and Bedford. In these the coal is inconstant and at its best only a local source of fuel. The Upper bench is of little or nó value and sometimes entirely wanting. To the south the coal thins and along the Ohio River is wholly wanting.

Bedford Township. The greater portion of this township holds the Pittsburg coal with a moderate thickness. The seam is locally termed the "Four Foot Vein," but more often has a thickness of 3 feet. It outcrops along Kingsbury Creek and the West Branch of Shade River. "Boulders" are characteristic of the fuel, and farmers will go many miles to get the Pomeroy or 8a coal for domestic purposes rather than use this seam.

The Pomeroy or 8a coal is everywhere present, from 15 to 25 feet above the Pittsburg, or No. 8, seam.

The streams in the eastern portion of the township often have narrow gorge like valleys, doubtless due to the resistance to erosion of the massive sandstone above.

The following section was taken near the eastern edge of section 20, where the Pittsburg coal dips below the bed of Kingsbury Creek:

	Ft.	In.
Sandstone, over 4 feet.		
Shales	2	0
Pomeroy coal, No. 8a	1	6

	Ft.	In.
Shales, blue	8	0
Shales with nodular limestone	11	0
Shaly sandstone	9	0
Pittsburg coal, No. 8	2	6+

The Pittsburg coal is extensively stripped in the southeast corner of section 15 on the land of H. Riggs, to supply the country demand.

A section of the coal is as follows:

		Ft.	In.
Shales, dark, unmeasured.			
Upper bench.	Coal	0	3
Soapstone		1	3
Lower bench	Coal	1	0
	Shales	0	1
	Coal	1	0
	Shales	0	1
	Coal	1	6

In section 9 a short distance east of this point the Pittsburg coal dips below the bed of the West Branch of Shade River.

In the Haning bank near the south edge of section 36, the coal is as follows:

	Ft.	In.
Shales, unmeasured.		
Coal	1	2
Clay streak		
Coal	1	10
Clay	0	½
Coal	0	11
Fire clay, unmeasured.		

Here the Lower bench of the seam only is present.

On the west side of Shade Creek the coal is usually thinner and the Upper bench entirely wanting. On the land of J. Bobo, northwest corner section 23, the following measurement was made by means of the hand level:

	Ft.	In.
Sandstone, unmeasured.		
Shales	10	0
Pomeroy coal, No. 8a	1	4
Shales	21	0
Pittsburg coal, No. 8	4	0
Clay containing limestone nodules	4	0

In the southern part of the township along Pratts' Fork, the Pittsburg coal is usually limited to the Lower bench and is known locally as the "Four-Foot Vein." The soapstone above the Lower bench does not make a good roof and therefore several inches of coal are left up to support the soapstone.

Near the eastern edge of section 25, the coal has been mined in the Sapps bank for the local market. The Lower bench only is found. It shows the following structure:

	Ft.	In.
Soapstone, unmeasured.		
Coal	1	0
Pyrites	0	½
Coal	1	8
Pyrites	0	1
Coal	1	0
Shales, unmeasured.		

The following section was taken at the entrance of the Williams bank in the northwest corner of section 19. As will be noted the Lower bench only of the coal is present.

		Ft.	In.
Dark shales, unmeasured.			
Shales		0	10
Lower bench	Coal	0	7
	Shale parting		
	Coal	1	4
	Shale parting		
	Coal	2	0
Dark shales		3	9
Limestone, impure		2	4
Shales, calcareous		3	0
Sandstone in bed of stream.			

The thickness of the coal in the mine is usually greater than shown in the section.

In this region the coal very often contains the pyrites—sandstone "boulders" so common in the Federal Creek region. They range from 2 to 10 feet in diameter and are so abundant that it is difficult to get miners to work the coal.

The downstream limit of the outcrop of the Pittsburg coal on Pratts' Fork is near the eastern edge of section 19.

Scipio Township. About one-half of this township is underlain with the Pittsburg coal, but the thickness is very changeable and uncertain. In the southern half of the township the seam is of little value, the Pomeroy coal being the seam worked in that locality. In the northern half of the township the Pittsburg coal ranges from 2 to 4 feet in thickness and contains much pyrites, hence the coal is not very desirable for domestic purposes.

The Ames limestone rises above drainage about the middle of the township. In this locality it consists of fossiliferous limestone nodules imbedded in shales. The following section was taken with an aneroid on the road a short distance west of Downington postoffice:

	Ft.	In.
Sandstone, unmeasured.		
Coal, Pomeroy, No. 8a	1	8
Calcareous shales	15	0
Coal, Pittsburg, No. 8	3	0
Shales	15	0
Massive sandstone	40	0
Shaly coal	0	4
Shales, red and gray	60	0
Red clay with nodular iron ore	20	0
Shales, gray	10	0
Ames limestone, nodular and imbedded in shales	15	0

Eastward from Downington Postoffice the Pittsburg coal gradually thickens, reaching nearly 4 feet in the eastern part of the township.

In the southeast corner of section 17 the Pittsburg coal is mined in the Suddeth bank. The structure of the coal is as follows:

	Ft.	In.
Clay, unmeasured.		
Coal	0	3
Clay streak		
Coal	1	6
Pyrites streak	0	½
Coal	0	9
Clay, unmeasured.		

This represents the Lower bench only, the Upper bench being absent.

In the southern part of the township a ledge of white limestone, about 10 inches thick, occurs 30 feet above the Ames limestone.

THE PITTSBURG COAL IN GALLIA COUNTY.

This seam is important in this county and is known locally as the Swan Creek, Lewis or Jeffers coal. It is of value in Ohio, Guyan, Clay, Harrison and Green townships only, and in one (Ohio) is shipped by river. The seam varies much in thickness from place to place, and is very similar in structure to the same seam in Northern Athens and the adjacent part of Morgan county.

Outside of the townships named in the preceding paragraph the coal is very thin and frequently is not represented by even a streak.

In previous reports of the Survey little attention was given to this coal. Andrews correctly identified the seam lying about 50 feet higher as the Pomeroy which he regarded as the Pittsburg, but the seam in question he did not classify.[1] Its structure and position with reference to the underlying Ames limestone and the overlying Pomeroy seam leaves no doubt as to its being the Pittsburg coal.

[1] Geol. Sur. of Ohio, Vol. I, pp. 225-246.

Ohio Township. This is one of the smallest townships in the county, but it contains considerable coal. The Pittsburg coal outcrops along the Ohio River and also along Swan Creek to the northern line of the township. Likewise the seam outcrops in the valley of Little Swan Creek. These valleys are narrow and hence the quantity of coal cut out is small.

While the Pittsburg coal underlies the whole of this township except where removed in valleys, it varies greatly from place to place. The areas where the coal has been demonstrated to be thick and important are small and confined to a strip just below Bladen along the Ohio River and to another small area along Swan Creek, almost due west of Bladen.

In the southeastern part of the township the coal appears to be very thin, perhaps entirely wanting, and the same is probably true along the extreme southern part of the township.

The coal is everywhere due along Little Swan Creek, and has been stripped in the bed of this stream in section 4. No banks have been opened, however, and the coal promises little in this locality.

The best known mine in the township is the "Klondyke," owned by the Swan Creek Coal Company of Gallipolis. The mine is located on the Ohio River a short distance below Bladen, and has been in operation about ten years. About 20 miners are employed except when the river is blocked by ice or the water is extremely low. Shipment is by river, and principally to Cincinnati. Section 25 was measured in this mine, the entrance to which is 570 feet above sea level.

Chemical analysis and calorific value of Section 25:

Ultimate.		*Proximate.*	
Carbon	64.94	Moisture	5.80(a)
Hydrogen	5.16	Volatile Matter	36.76
Oxygen	14.40	Fixed carbon	47.38
Nitrogen	1.10	Ash	10.06
Sulphur	4.34		
Ash	10.06		
	100.00		100.00

Calorific value ....6,551 calories(b).

(a) Moisture in the air-dried sample about 3%.

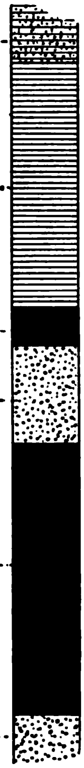
(b) The ultimate analysis and calorific value here given were not obtained until several weeks after the preparation of the fine sample, and laboratory experiments indicate that the sample had increased in weight by oxidation about 1½%. A calorific value about 100 calories higher than that given appears to more nearly represent the fresh sample.

The sample included parts 2 and 4 of the section, and was 10 inches wide and 2 inches deep.

The Upper bench is thin and unimportant, sometimes absent. Much the same is true of the soapstone below. According to the miners the latter rarely exceeds 12 inches and occasionally is wanting. About two

SECTION 25

	Ft.	In.
6. Massive sandstone,		
5. Shale, reported,	2	6
4. Upper bench, Coal,	0	4½
3. Soapstone,	1	0
2. Lower bench, Coal,	2	9
1. Clay, unmeasured,		



feet above the bottom of the seam a fairly persistent thin band of pyrites was found, and occasionally a streak of bone coal.

The Lower bench is not undercut but shot on the solid. Next the soapstone is pulled down and finally the Upper bench or top coal is removed.

The shales overlying the coal are reported to vary in thickness from one to fourteen feet. Above these is a massive sandstone.

North and south from this mine the coal thins rapidly, making the workable area along the river front very narrow.

Below is a section of the coal in the William Elliot mine in section 29, on the western bank of Swan Creek:

	Ft.	In.
Shales, unmeasured.		
Upper bench. Coal	0	5½
Shales	1	7
Lower bench. Coal	3	4
Shales, unmeasured.		

The shale parting separating the two benches ranges from 4 to 25 inches in thickness. The Upper bench coal varies from 5½ to 10 inches,

and the Lower bench usually from 36 to 40 inches. This mine has been in existence for perhaps 20 years, and supplies a local demand.

About 100 yards north of the Elliot bank is that of Samuel Lewis, in which the following section was measured:

		Ft.	In.
Shales, unmeasured.			
Upper bench	Coal	1	3
	Shale	0	2½
	Coal	1	6
	Coal and shale	2	7
Draw slate (clay)		0	11
Lower bench. Coal		3	0

The draw slate is reported to range from one to fifteen inches in thickness and to average 6.

This mine supplies a local trade, and has been worked for about 15 years. At the entrance of the mine the coal is 592 feet above sea level. Other mines have been opened in this vicinity.

In the extreme northwestern corner of section 30 on land of Thomas Erwin the coal is found in the bed of Swan Creek, and is reported to measure as follows:

		Ft.	In.
Upper bench	Coal	1	6
	Shale, dark	2	6
	Coal	0	6
Draw slate (clay)		0	10
Lower bench. Coal		3	2

Coal No. 8a (Pomeroy) is reported 32 feet higher and 15 inches in thickness.

Clay Township. What has been said about the Pittsburg coal in Ohio township applies very well to the same seam in Clay. However, the coal appears to be steadier in thickness in this township than in Ohio, and in consequence is more widely worked. Especially is this true south of Raccoon Creek where the coal is mined at numerous points from Yellowtown, southeast, to near Chambersburg.

North of Raccoon Creek the seam is much thinner and is rarely mined. It is the Pomeroy or 8a coal that is worked there, and this, too, is of little importance.

At Yellowtown the coal is 705 feet above sea level. It has long been mined at a number of places in this vicinity for local trade. The following section was measured in the entry of a new bank on the hill just south of the village:

	Ft.	In.
Shales, dark	4	0
Upper bench. Coal	1	0
Shales	2	0
Lower bench. Coal	2	10
Clay, unmeasured.		

The seam is or has been worked at several places east of Yellowtown, on the south bank of Raccoon Creek. However, the coal there is thin.

At the entry to the Elizabeth Dodd bank, two miles southeast of Yellowtown the following measurement was made:

	Ft.	In.
Shale, dark	4	6
Upper bench. Coal	1	0
Shales	0	10
Lower bench. Coal	3	1
Clay, unmeasured.		

The coal is at its best on Teens Run and Little Teens Run in the southeastern part of the township.

The following section was made in the Hazlett bank on Little Teens Run:

		Ft.	In.
Sandstone		12	0
Shale, light		1	6
Upper bench	Coal	2	0
	Shale, black	2	4
	Coal	0	8
Shales		0	8
Lower bench	Coal	1	8
	Pyrites band	0	1
	Coal	1	8

The band of pyrites in the Lower bench is very hard and quite persistent. This bench ranges from 3 to 3½ feet in thickness and is quite steady. The Upper bench is divided into two parts by a bed of shales of unusual thickness. The coal below the shales is fairly uniform, but that above varies much owing to the changing thickness of the shales. The Lower bench only is worked. This mine has been in operation in an irregular way for about forty years.

The 8a or Pomeroy coal is found along this run, about 27 feet above the Pittsburg seam and is reported 18 inches in thickness.

On Teens Run the coal has been opened at several places, but the best known mine is the Jeffers. The following section was furnished by Mr. Jeffers:

	Ft.	In.
Shales, black, unmeasured.		
Upper bench. Coal	1	0
Shales	1	0
Lower bench. Coal	3	0

The shales above the Lower bench were reported to vary from 3 to 24 inches in thickness. Probably the section of the Upper bench is incomplete, the coal above the black shale being omitted.

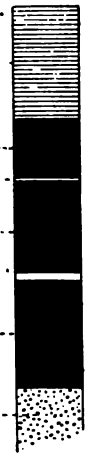
South from Teens Run the coal thins, decreasing in value until the Swan Creek field in Ohio township is reached when it again becomes

of value. While Clay township will probably never be a larger producer of coal, it nevertheless contains an ample supply for local use.

Green Township. The Pittsburg or No. 8 coal in this township appears to be restricted to sections 7 and 8, just east of Raccoon Creek. Mining is done only in section 8, and it may be that in section 7 to the south the coal is wanting. The coal is due in the high hills in the southeastern quarter of the township, but as already stated is usually absent. Section 26 was measured in the Odell bank in section 7.

SECTION 26

	Ft.	In.
7. Shale,	1	2
6. Coal,	0	7
5. Parting,	0	1/8
4. Coal,	0	11
3. Parting,	0	3/4
2. Coal,	1	1
1. Clay, unmeasured,		



About 20 feet higher in the hill the Pomeroy or 8a coal is found, and is reported by Mr. Odell to be from 18 to 20 inches thick.

Chemical analysis and calorific value of Section 26:

Ultimate.		*Proximate.*	
Carbon	62.30	Moisture	6.73(a)
Hydrogen	5.11	Volatile Matter	34.34
Oxygen	14.05	Fixed carbon	45.90
Nitrogen	1.14	Ash	13.03
Sulphur	4.37		
Ash	13.03		
	100.00		100.00

Calorific value .... 6,356 calories.

(a) Moisture in the air-dried sample about 3%.

The sample included the entire section except parts 1, 3 and 7, and was 10 inches wide and 2 inches deep.

Guyan Township. The Pittsburg or Swan Creek coal while due in the hills throughout this township, is found only in the northeast corner in sections 11, 12 and 18. Elsewhere in the township the seam is wanting or is represented by a streak only.

Near the village Mercerville two seams are or have been worked. These are shown on or near the Robinson farm just north of the village. The lowest of these seams is the Pittsburg or No. 8. In the entry of an old bank the following measurement of this coal was made:

	Ft.	In.
Shale, unmeasured.		
Rotten coal	0	6
Shale	3	0
Coal. Upper bench	1	0
Soapstone	0	10
Coal. Lower bench	2	8

A few hundred feet southeast of this locality is a small bank where a little mining has been done. In the entry of this bank the section was as follows:

	Ft.	In.
Shales, thickness exposed	6	0
Coal	1	10

This coal is 51 feet above the Pittsburg. It is classed with the Pomeroy or 8a seam which is of importance in this part of the state. The interval given was measured with a hand level.

About three-fourths of a mile northwest of Mercerville on the Wood's farm, the two coals are found, the lower or Pittsburg 1 foot thick and the Upper or Pomeroy 3 feet, the interval between the two being about 40 feet.

For the facts here stated and for many courtesies, the survey is indebted to Mr. F. B. Niday of Mercerville.

Harrison Township. The two eastern rows of sections in this township contain a valuable bed of the Pittsburg or Swan Creek coal. West of these sections the coal thins rapidly and is not workable, often in fact is not represented even by a black streak. Much the best of the coal is found in the ridge between Little and Big Bull Skin Creeks. However the coal is in good thickness on the east side of the latter creek, and is mined at several places. From this territory the coal extends east into Clay township, where as elsewhere stated it is a valuable local source of fuel.

Following is a section of the coal in the R. A. Lewis bank, section 16, in the ridge east of Little Bull Skin Creek:

		Ft.	In.
Shales, black		6	0
Soapstone		0	10
Upper bench. Coal		3	9
Clay		0	2
Lower bench	Coal	1	0
	Pyrites streak	0	½
	Coal	1	8
Clay, unmeasured.			

The Lower bench is fairly uniform in thickness but the Upper bench varies greatly, the result being marked changes in the total thickness of the seam. Thus 100 feet from the section just given the coal measures only 3 feet. The altitude of the seam at the entrance to the bank is 760 feet above sea level.

The Pomeroy or 8a coal is found here about 30 feet above the Pittsburg seam, but appears to be too thin to be of value.

Quite a number of mines are found on both sides of Big Bull Skin Creek, making the territory one of the best known mining districts in the county. These banks supply the neighboring farmers and also many tons for Gallipolis, transportation being by wagon.

Below is a section of the coal in the Irions bank, southeastern quarter of section 7:

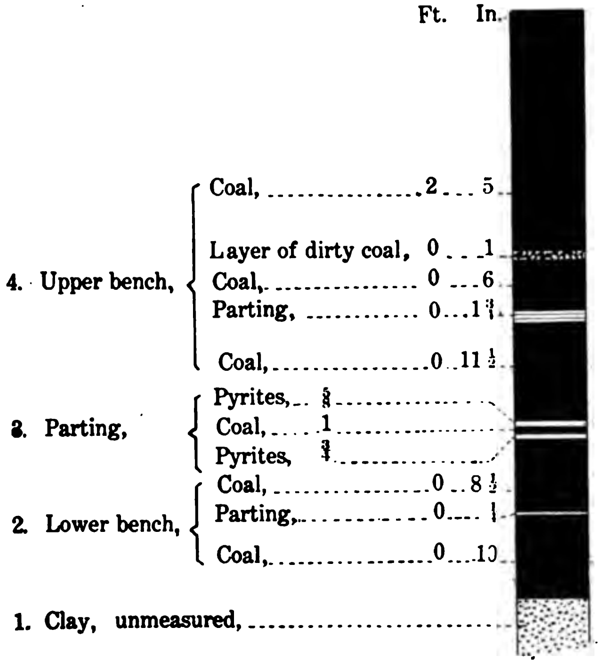
	Ft.	In.
Shale, black	2-4	
Upper bench. Coal	0	10
Shale	0	4
Lower bench. Coal	2	10

Another layer of coal is reported above the black shales referred to in the above section. It probably represents the Roof coal.

The shales above the Lower bench vary much in thickness, changing from 4 to 15 inches in the space of 20 feet.

In the Kerns bank in the northeast quarter of section 6 the coal was found as shown in Section 27.

SECTION 27



Two fairly persistent pyrites layers were found in this mine. Each attains a maximum thickness of 3 inches, but occasionally disappears. The seam here varies from 4 to 8 feet in thickness.

Chemical analysis and calorific value of Section 27:

Ultimate.		*Proximate.*	
Carbon	64.91	Moisture	6.98(a)
Hydrogen	5.24	Volatile Matter	36.14
Oxygen	14.60	Fixed carbon	47.85
Nitrogen	1.01	Ash	9.03
Sulphur	5.21		
Ash	9.03		
	100.00		100.00

Calorific value ....6,583 calories.

(a) Moisture in the air-dried sample about 3%.

Parts 1 and 3 of the above section were rejected in the sample which measured 4 by 2 inches.

On the Lewis farm, adjoining the Kerns on the north, the coal is similar to that given in the preceding section with an additional layer 2 feet in thickness above the shales which form the roof. This layer of coal is probably the equivalent of the one referred to in the Irions bank. It is not mined. Irregular pyrite bands are found in this mine.

In the mine of A. V. Houck the coal was found as shown in Section 28.

This section shows resemblance to the same seam in the eastern part of the state. The Roof coal has the complex structure occasionally found in Belmont and adjacent counties. The shale below the Roof coal represents the Draw slate; the Upper bench, here thin, the Breast coal; the soapstone, the Bearing in horizon, and the Lower bench the Brick and Bottom coals. Whether this coincidence is more than a lucky accident cannot be said.

This mine helps supply the surrounding country and to a small extent the county seat, Gallipolis.

Chemical analysis and calorific value of Section 28:

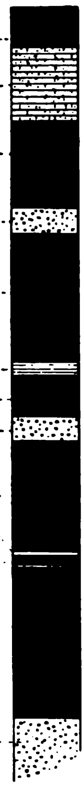
Ultimate.		*Proximate.*	
Carbon	64.59	Moisture	7.83(a)
Hydrogen	5.18	Volatile Matter	34.15
Oxygen	15.49	Fixed carbon	48.26
Nitrogen	1.09	Ash	9.76
Sulphur	3.89		
Ash	9.76		
	100.00		100.00

Calorific value ....6,544 calories.

(a) Moisture in the air-dried sample about 3%.

SECTION 28

		Ft.	In.
6. Roof coal, reported,	Coal,	0	5
	Sandstone,	0	9
	Coal,	0	10
	Soapstone,	0	3
	Coal,	1	3
5. Dark shale,		0	2
4. Upper bench,	Coal,	0	4½
3. Soapstone,		0	3
2. Lower bench,	Coal,	1	1
	Parting,	0	¼
	Coal,	0	1
	Parting, very thin,		
	Coal,	1	5¾
1. Clay,			



This sample was taken from parts 2 and 4 of the section, these being the only portions of the seam marketed.

Northeast from the Lewis bank the Pittsburg or Swan Creek coal thins and is of much less value. On the G. W. Lusher farm along the west bank of Raccoon creek in section 12 the coal was reported by the proprietor as follows:

	Ft.	In.
Upper bench. Coal	3	0
Shales	1	8
Lower bench. Coal	2	8

The 8a or Pomeroy coal is reported in this hill, and about 20 inches in thickness. A short distance up the creek it has been mined.

This section shows thick limestones between the two coals, similar to what have been reported in Pennsylvania and West Virginia. Farther west and southwest in Ohio the limestones are much thinner, but have been traced to the Ohio river at Pomeroy.

Below is a partial record of a diamond drill test made in section 10 of Wayne township in the southwestern part of Belmont county. Only that part of the record is given which shows the relative positions of the Pomeroy or Redstone and the Pittsburg coals.

	Ft.	In.
Limestone	3	4
Soapstone with lime nodules	3	0
Pomeroy or Redstone coal, No. 8a, (Coal and shale)	1	3
Fire clay	1	0
Gray shale	3	2
Black shale	1	0
Limestone	5	6
Limestone and shale	2	0
Limestone	3	0
Lime, fire clay	2	0
Gray shale with limestone nodules	3	0
Greenish shale	1	6
Dark shale, carbonaceous	3	2
Pittsburg coal { *Roof coal*	0	10
Pittsburg coal { *Draw slate*	1	0
Pittsburg coal { *Coal*	5	7
Fire clay	4	1

Frequent exposures of the seam are found in Jefferson county. The following section was measured by the late Professor C. N. Brown in section 22 of Smithfield township.

	Ft.	In.
Shales, exposed	10	0
Pomeroy or Redstone coal, No. 8a	2	1
Clay streak		
Limestone	2	0
Clay shales	11	0
Pittsburg coal (Roof coal)	2	1
Draw slate	1	0
Black slate	0	1
Pittsburg coal (Breast coal) No. 8	2	4

This section shows an interval of only 13 feet between the two seams, while in Belmont county, as the sections show, the interval is materially larger.

From Belmont county the coal can be traced southwest through Noble and Morgan counties, but in both of these the exposures of the seam are fewer and less prominent.

In his report on the Meigs Creek coal in the last two counties named in the above paragraph, Professor Brown makes occasional mention of a seam lying between the horizon of the Meigs Creek and Pittsburg

coals. Thus in Wayne township in the northeastern part of Noble county, he mentions a faint coal mark at from 50 to 55 feet below the Meigs Creek. Likewise he speaks of a thin seam of coal about 60 feet below the Meigs Creek in Elk township in the southwestern part of the county.[1] The position of the seam is from 20 to 30 feet above the horizon of the Pittsburg in the localities mentioned and it is plainly the Pomeroy or Redstone coal.

In the northern part of Meigsville township, Morgan county, Professor Brown found the Pomeroy or Redstone coal from 12 to 20 inches thick, about 26 feet above the Pittsburg seam.

West of the Muskingum river the Pittsburg and Pomeroy coals are very thin or wanting until the southwestern part of the county (Morgan) is reached where the Pittsburg coal suddenly increases in thickness and becomes a workable seam.

Structure of the Pittsburg Coal in Southwestern Morgan and Northern Athens Counties.

It will be well at this point to note the structure of the Pittsburg coal in the territory just referred to where it is commonly known as the Federal Creek seam. For the convenience of the reader a few sections will be given which have already appeared in the chapter on the Pittsburg coal.

Section of coal in the Waymer bank, near Joy in the southwestern part of Morgan county:

		Ft.	In.
Coal, Upper bench	Coal	1	6
	Bone coal	0	8
Clay or shales		0	11
Coal, Lower bench	Coal	0	2
	Parting	0	⅛
	Coal	0	7½
	Parting	0	½
	Coal	0	3
	Parting	0	⅜
	Coal	0	1½
	Parting	0	⅝
	Coal	2	0

A few miles farther south in Athens county a number of mines exist, three of which ship by rail. In the one at Broadwell the coal was found as follows:

		Ft.	In.
Coal, Upper bench	Coal	1	3
	Bone coal	0	3½
	Coal	0	4
Clay or shales		1	0

[1] Geol. Sur. of Ohio, Vol. V, chapter XIX.

		Ft.	In.
Coal, Lower bench	Coal	0	6
	Parting		
	Coal	0	2
	Parting	0	$\frac{1}{4}$
	Coal	2	5

These sections are typical for this part of the state. It will be seen that the coal consists of two benches separated by a prominent layer of shales or clay, called soapstone by the miners. This structure of the Pittsburg seam is very persistent in southern Ohio, and may be found wherever the coal exists in anything like normal thickness. It is further illustrated by sections on following pages.

The Pomeroy Coal from the Hocking River in Athens County South to the Ohio River.

In Alexander township, Athens county, the Pomeroy coal is usually found where due, though frequently it is little more than a blossom. The coal is usually about 20 feet above the Pittsburg.

Near the Bennett mine in section 4 of this township, the following section was measured:

	Ft.	In.
Shales, unmeasured.		
Pomeroy coal, No. 8a	1	0
Shales with nodular limestone	20	6
Pittsburg coal, No. 8	4	0
Shales	8	0
Sandstone, unmeasured.		

The nodular limestone mentioned in the last two sections is important in the identification of the two coals. It is rarely a foot thick, but is persistent and has been traced to the Ohio river at Pomeroy where the lower or Pittsburg coal is not represented by even a black streak. In this part of the state limestones are not common and this fact increases the value of the stratum in question for stratigraphical purposes.

Lodi township lies east of Alexander and contains the Pomeroy coal where due, the thickness usually ranging from 12 to 18 inches. Occasionally the coal is underlain by several feet of white limestone. The coal is not mined in the township except where it can be stripped.

Going south from Lodi township, Bedford township, Meigs county is reached. Here the Pomeroy seam is found about 20 feet above the Pittsburg and about 20 inches thick. It is not mined except by stripping.

On the Mayhugh farm in section 21 the coal was found as follows:

	Ft.	In.
Coal	0	8
Shales	0	10
Coal	1	8

On the same farm the lower or Pittsburg seam has been mined by stripping in the bed of a creek.

In the southeast corner of this township both coals are well shown and the locality is important in demonstrating the correct position of the Pomeroy seam. About one mile due north of the hamlet Midway the Pittsburg coal is stripped in the bed of a run on the Riggs farm, where the following section was measured.

		Ft.	In.
Shales, unmeasured.			
Coal, Upper bench		0	3
Clay or shales		1	3
Coal, Lower bench	Coal	1	0
	Shales	0	1
	Coal	1	6
	Shales	0	1
	Coal	1	6

It will be noted that the Upper bench here is thin. In fact where the coal contracts this bench suffers most and not infrequently disappears. On the hill between this stripping and Midway the upper or Pomeroy coal is found and the thin limestone below it.

On Kingsbury Creek due south of Midway the Pittsburg coal is below drainage having dipped beneath the bed of that stream about one mile farther up, where the following section was measured.

	Ft.	In.
Sandstone, unmeasured.		
Shales	2	0
Pomeroy coal	1	6
Shales, blue	8	0
Shales with limestone	11	0
Sandstone, shaly	9	0
Pittsburg coal, unmeasured.		

A few hundred yards up stream from where this section was taken the Pittsburg coal has been stripped in the bed of the creek.

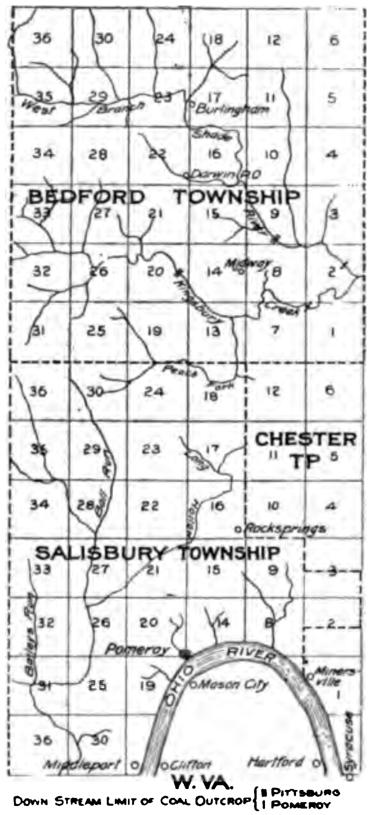
From Kingsbury Creek the Pomeroy coal can be followed up a tributary, Peach Fork, at least three miles.

In following up this tributary one crosses from Bedford township into Salisbury which contains the most valuable deposit of the Pomeroy coal above drainage in Ohio. The structure of the seam along Peach Fork on the northern edge of Salisbury township is as follows:

		Ft.	In.
Sandstone		30	0
Shales		4	0
Pomeroy coal	*Coal*	0	3
	Shales	0	1
	Coal	1	8
Shales		2+	

The coal has been worked to a very small extent by the farmers. Everywhere along this stream the Pittsburg coal is below drainage and so was not seen. At one place it was reported to have been struck in digging a well, its position being 30 feet below the Pomeroy seam.

Crossing the divide to the southwest from the head of Peach Fork the valley of Ball Run is entered and the Pomeroy coal is found in similar position and thickness to that on the first named stream. The position of the coal, immediately under the massive sandstone is important.



BEDFORD AND SALISBURY TOWNSHIPS, MEIGS COUNTY

Southward on Ball Run the coal increases rapidly in thickness and is mined in a small way at a number of places. It can easily be followed along this stream to the valley of the Ohio. Nowhere in this locality, however, was the Pittsburg coal found though conditions for its exposure are excellent. In fact it is not represented by even a black streak. At Pomeroy the persistent band of limestone which has already been referred to was found below the Pomeroy coal.

The structure as well as the thickness of the Pomeroy coal changes

to the south. On the Gilmore farm, north edge of section 28, Salisbury township, on Ball's Run, the coal was found as follows:

	Ft.	In.
Sandstone	30	0
Coal	1	6
Shales	0	6
Coal	0	4
Clay, unmeasured.		

On the south side of this section the coal measures 4 feet. Where the coal is thin in Athens and Meigs counties, it is usually divided into two parts by a layer of clay or shales. The structure then resembles that of the Pittsburg, but as has been shown the two coals are frequently found on the same hillside and so have not been confused.

The Pomeroy Coal at Pomeroy and Vicinity.

The structure of the Pomeroy coal at Pomeroy and vicinity forms a marked contrast with that of the Pittsburg seam in southern Ohio. As has already been shown the Pittsburg consists of two prominent benches of coal separated by a layer of shales or clay, this structure being very persistent. The Pomeroy seam on the other hand does not have such a characteristic structure. This is well shown by the following sections:

Section in the Logan Mine, Pomeroy.

	Ft.	In.
Bone and dirty coal	1	3
Coal	1	8
Parting less than ⅛ inch.		
Coal	0	3
Parting very thin.		
Coal	2	3
Clay, unmeasured.		

Section in the Mine of the Peacock Coal Co., Pomeroy.

	Ft.	In.
Shales, reported thickness	2	0
Impure coal	0	6½
Bone coal	0	5½
Coal	3	3

A few miles up the river the coal was found as follows:

Section in the Bartel's Mine, Syracuse.

	Ft.	In.
Sandstone, unmeasured.		
Impure coal	0	7½
Horn coal	0	5½
Coal	1	4
Horn coal	0	2½
Coal	2	3½
Clay, unmeasured.		

Still farther up the river at Antiquity the coal is mined by shafting, the seam being 100 feet below low water. The coal is as follows:[1]

	Ft.	In.
Coal with a bony band	2	6
Slate	0	2
Coal	3	0

It may not be amiss to give a section on the West Virginia side of the river. The coal was found as follows in the mine of the West Virginia Salt and Coal Company, near Hartford.[2]

		Ft.	In.
Sandstone.			
Slate			
Draw slate		0	1
Coal	Top coal	0	7
	Horn coal	0	2
	Coal	3	9

Other sections from that side of the river might be given but they would in a large measure duplicate the above.

These sections show a marked difference in structure between the Pomeroy coal and the Pittsburg as found on Federal Creek and vicinity, but a striking resemblance to the Redstone coal of Pennsylvania and West Virginia as shown in the first part of this chapter.

The Pomeroy Coal in Gallia and Lawrence Counties.

In Gallia county farther west the structure of the Pomeroy coal becomes more simple, consisting generally of a solid block, but occasionally having one or more shale parting.

Both the Pittsburg and Pomeroy coals are found in the eastern part of the western half of Gallia county. Still farther west the Pittsburg seam wholly disappears, leaving the Pomeroy the only seam in the hills and this is thin and of value for domestic purposes only.

Andrews classed the higher of the two seams as the Pomeroy, but the lower or Pittsburg seam he did not correlate with any seam found elsewhere in Ohio. As is well known he regarded the Pomeroy coal as the Pittsburg.

This field furnishes very strong evidence on the position of the Pomeroy coal, for this seam can be followed from hill to hill all the way from Pomeroy to the territory under consideration, and thus the identity of the seam in the two counties is proven.

In at least five townships in Gallia county where the Pomeroy coal exists, another seam is found from about 25 to 55 feet lower. This seam is in a number of localities much more prominent than the Pomeroy, and is known locally as the Swan Creek, Jeffers or Lewis seam. The structure of the coal is shown in the following sections:

[1] West Va. Geol. Sur., Vol II, p. 194.

[2] Ibid., p. 193.

Section in mine of the Swan Creek Coal Co., near Bladen on the Ohio river:

	Ft.	In.
Sandstone, massive.		
Shales, reported thickness	2	6
Coal, Upper bench	0	4½
Soapstone	1	0
Coal, Lower bench	2	9
Clay, unmeasured.		

The section shows the coal of the Upper bench thin. It is in fact sometimes wanting in this mine. The soapstone below also varies. Rarely is it more than a foot thick and occasionally it disappears.

Section in the mine of Samuel Lewis on Swan Creek in section 29 of Ohio township:

		Ft.	In.
Shales, unmeasured.			
Coal, Upper bench	Coal	1	3
	Shales	0	2½
	Coal	1	6
	Coal and shale	2	7
Clay		0	11
Coal, Lower bench		3	0

Here the upper bench is thicker and more complex in structure.

These two sections can be duplicated in large number and in several townships. Generally the Upper bench is thin and comparatively unimportant, but occasionally it is of more value than the Lower bench. The structure of the coal is strikingly similar to the Pittsburg coal on Federal Creek in Athens and Morgan counties, already given. In both localities the seam is divided into two benches by a bed of clay or shales. Further the relation of the seam in the two localities is similar with reference to the Ames or Crinoidal limestone. That the coal on Federal Creek is the Pittsburg there can be no doubt, and the same conclusion is necessarily reached with reference to the Swan Creek, Jeffers or Lewis seam of Gallia county.

It remains now to show the position of the Pomeroy seam in this territory with reference to the lower or Pittsburg. On or near section 28, Guyan township in the southwestern corner of Gallia county, the following section was measured with a hand level:

	Ft.	In.
Sandstone	40	0
Coal, Pomeroy or 8a	3	6
Partly covered, sandstone seen	27	0
Coal blossom, Pittsburg or No. 8		
Shales	15	0

One more section from Gallia county will be given. This is on section 26 of Clay township, and is taken from Professor Andrew's report:[1]

[1] Geol. Sur. of Ohio, Vol. I, p. 240.

	Ft.	In.
Sandstone, unmeasured.		
Pomeroy coal	1	6
Not exposed	30	0
Sandy shale	10	0
Clay shale	3	0
Top coal	2	0
Ferruginous black slate	2	0
Coal — *Coal*	0	10
Coal — *Clay*	1	0
Coal — *Coal*	3	6
Clay	2	6

While Andrews does not name the lower coal, it is clear from his text that he regards it as the Jeffers seam, which as has elsewhere been stated is the Pittsburg. In fact this section was taken at the mine of Abram Jeffers. The "Top coal" of the section is what is elsewhere known as the Roof Coal of the Pittsburg seam.

In Lawrence county the Pittsburg coal is rarely seen and probably is never more than a black streak. The following section was obtained in the northwest quarter of section 25 of Mason township:

	Ft.	In.
Sandstone	25	
Shales	11	0
Coal, Pomeroy	4	0
Fire clay	2	0
Limestone	1	0
Shales	19	0
Coal blossom, Pittsburg	0	6
Fire clay	1	0

Not only does this section show both coals but also the limestone between them, which as has already been stafed, is important in identfying the two seams.

Conclusion.

To the writer the proof is conclusive, the Pomeroy coal lies above the Pittsburg and is the equivalent of the Redstone seam. Since, however, the name Pomeroy is in general use in Ohio it will be retained. The Pittsburg coal being known as No. 8 and the Meigs Creek as No. 9, the Pomeroy seam may appropriately be numbered 8a. For the massive sandstone overlying the Pomeroy coal, the name Pomeroy is proposed.

THE POMEROY COAL IN MEIGS COUNTY.

The Pomeroy coal is at its best in this county. It is found above drainage wherever due and in the southern part becomes one of the important coal fields of the state

In the northern part of the county the seam is underlain by the

Pittsburg, and between them is usually found a thin bed of limestone. Farther south the Pittsburg coal entirely disappears.

Overlying the Pomeroy coal is a massive sandstone for which the name Pomeroy is proposed. Sometimes it rests directly on the coal, but occasionally it is separated from the coal by a bed of shales of varying thickness. The sandstone is persistent, being found over extensive areas.

Salisbury Township. This township has been an important source of fuel from almost the time of settlement of the territory. Then as now salt making was a leading industry and naturally coal was used quite largely as fuel. The river provided cheap transportation and the coal was shipped to Cincinnati and other river markets. With the construction of railroads a direct outlet has been provided to the Great Lakes and the Northwest. This has resulted in the opening of new mines and a large increase in coal production.

Throughout the township the coal lies either directly under the Pomeroy sandstone or is separated from it by a thin bed of shales. A few feet below the coal there is found the thin stratum of limestone which is so persistent between the Pittsburg or No. 8 and the Pomeroy or 8a seams. This limestone was found within the city limits of Pomeroy, showing that the stratum in question reaches as far south at least as the Ohio River.

The township is a larger producer of the Pomeroy or 8a coal than any other township in Ohio. Along the eastern line of the township the coal is under cover except on the Ohio River and two or three tributary streams. On the western side of this township the coal is high in the hills, but is mined for railroad shipment as far west as the vicinity of Rutland.

In the northwestern part of the township the coal is thin and of little value, but farther south and east the seam thickens rapidly, and soon becomes of decided value.

In the northern part of the township the coal is thin but persistent and uniform in thickness. From Pomeroy the Pomeroy or 8a coal may be traced with scarcely any break north into Bedford township where the No. 8 coal, about 20 feet lower becomes workable. Along Peach Fork in the northern part of the township the 8a coal outcrops under the sandstone continuously for several miles and has been mined in a very small way at many places. The following section shows the structure of the coal along this stream.

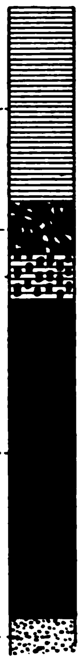
	Ft.	In.
Sandstone	30	0
Shales	4	0
Coal	0	3
Shales	0	1
Coal	1	8
Shales, blue	2+	

In the same vicinity the Pittsburg or No. 8 coal was reported to have been found in a well 30 feet below the 8a coal.

Section 29 shows the coal as found in the mine of the Peacock Coal Company at Pomeroy.

SECTION 29

	Ft.	In.
5. Shale, reported thickness,	2	0
4. Impure coal,	0	6½
3. Bone coal,	0	5½
2 Coal,	3	3
1. Clay, unmeasured,		



The mine is an old one, having been first worked about the time of the Civil war. In the hill facing the river the coal has been worked out, and mining is now done farther back. During the past few years the coal has been cut by machinery, but prior to that time the work was done by hand.

Where this coal is used in the salt furnaces the impure and bone coal are both retained, but when the fuel is shipped both are thrown out. No regular bands of pyrite were noticed, but irregular pieces of this exist near the base of the coal.

Chemical analysis and calorific value of Section 29:

Ultimate.		*Proximate.*	
Carbon	66.71	Moisture	7.83(a)
Hydrogen	5.53	Volatile Matter	34.59
Oxygen	15.96	Fixed carbon	49.39
Nitrogen	1.06	Ash	8.69
Sulphur	2.05		
Ash	8.69		
	100.00		100.00

Calorific value ....6725 calories.

(a) Moisture in the air-dried sample about 4%.

The sample included only part 2 of the above section. No pyrites occurred in the sample but is occasionally found in the seam especially near the bottom. The sample was about 5½ inches wide and 1½ inches deep.

Section 30 was measured in the Logan mine at Pomeroy.

SECTION 30

	Ft.	In.
7. Bone and dirty coal,	1	3
6. Coal,	1	8
5. Parting, less than ⅛ inch,		
4. Coal,	0	3
3. Shale parting, very thin,		
2. Coal,	2	3
1. Clay, unmeasured,		

The upper 15 inches of the coal are mined but usually not mixed with the main body of the seam. The coal supplies a local market only. The altitude of the seam at the entrance to this mine is 613 feet.

Chemical analysis and calorific value of Section 30:

Ultimate.		*Proximate.*	
Carbon	66.47	Moisture	7.22(a)
Hydrogen	5.39	Volatile Matter	32.82
Oxygen	16.43	Fixed carbon	50.67
Nitrogen	1.10	Ash	9.29
Sulphur	1.32		
Ash	9.29		
	100.00		100.00

Calorific value .... 6668 calories.

(a) Moisture in the air-dried sample about 4%.

This sample included the entire seam because it is all commonly marketed. The section measured 7 by 2 inches.

The Pittsburg mine at the upper end of Pomeroy is not above the high water mark of the Ohio river and the mine was flooded in the spring

of 1907. As a result a "squeeze" took place along about 500 feet of the entry.. The fire clay at the bottom of the coal softened and was pressed out by the weight of the overlying rock, and the track with cars on it was flattened against the roof.

One more section of the coal in this township will be given. This is from the mine of W. D. Edwards near Hobson station, and is shown in Section 31.

SECTION 31

	Ft.	In.
9. Horn and dirty coal,	1	10
8. Coal,	0	9
7. Horn coal,	0	¾
6. Coal,	0	10
5. Impure coal,	0	¼
4. Coal,	2	6
3. Impure coal,	0	¼
2. Coal,	1	9½
1. Clay, unmeasured,		

At 18 and 27 inches above the base of the coal streaks of pyrites were noticed, but these did not appear persistent. The coal supplies a local market and is shipped in a small way by rail. The latter method requires hauling by wagons from the tipple to a switch where the coal is shoveled into cars. In this locality the seam is well up in the hill.

Chemical analysis and calorific value of Section 31:

Ultimate.		*Proximate.*	
Carbon	65.55	Moisture	5.51(a)
Hydrogen	5.40	Volatile Matter	38.19
Oxygen	13.35	Fixed carbon	45.72
Nitrogen	0.95	Ash	10.58
Sulphur	4.17		
Ash	10.58		
	100.00		100.00

Calorific value..6661 calories.

(a) Moisture in the air-dried sample about 4%.

This entire seam is marketed and for this reason was included in the sample, except a few inches at the top where the sandstone wedged in. The sample measured about 7 by 1 inch.

Rutland Township. This township probably ranks next to Salisbury in the production of the Pomeroy or 8a coal. The territory is largely drained by Leading Creek and its tributaries which have perhaps cut out one-half of the seam.

The best coal of the township is found in the three southern rows of sections. Farther north the coal thins rather abruptly, and the Pittsburg or No. 8 seam commences to increase in thickness.

The K. & M. R. R. furnishes good shipping facilities, and the coal is mined in a large way as far west as Rutland.

Section 32 was taken in the mine of Maynard Brothers about one mile south of Rutland.

This mine was opened in 1905 and has a daily capacity of 300 tons. Mining is done with pick and shipment is by rail. No pyrites was seen and it was reported quite rare.

Chemical analysis and calorific value of Section 32:

Ultimate.		*Proximate.*	
Carbon	65.29	Moisture	7.63(a)
Hydrogen	5.20	Volatile Matter	33.33
Oxygen	15.72	Fixed carbon	48.11
Nitrogen	1.03	Ash	10.93
Sulphur	1.83		
Ash	10.93		
	100.00		100.00

Calorific value..6512 calories.

(a) Moisture in the air-dried sample about 4%.

The sample included parts 2, 3, 4, 8, 9, 10 and 12 of the section. No pyrites was noted in the sample and was reported to occur rarely. The sample measured about 5½ by 1 inch.

The northern boundary of the workable Pomeroy coal is usually

SECTION 32

		Ft.	In.
14.	Pomeroy sandstone, unmeasured,		
13.	Shale,	3	0
12.	Top coal,	0	6
11.	Impure coal,	0	7
10.	Coal,	0	3
9.	Parting,	0	¼
8.	Coal,	1	0
7.	Parting,	0	1
6.	Coal,	0	1
5.	Shale, parting,	0	⅜
4.	Coal,	1	3
3.	Splint coal,	0	2¾
2.	Coal,	2	4
1.	Clay, unmeasured,		

rather sharp and well defined. Near the boundary the coal is often found in an abnormally large thickness with several shale partings unknown in the principal territory of the seam. These features are well shown in the John Musser bank on Hysell Run about 2 miles northeast of Rutland. The structure of the coal there is as follows.

	Ft.	In.
Dark shale, unmeasured.		
Coal	1	6
Shale	1	6
Coal	1	2
Shale	0	1
Coal	2	0

	Ft.	In.
Shale	0	2
Coal	2	9
Fire clay, unmeasured.		

A few hundred yards north of this mine the coal is said to be less than two feet in thickness.

In the valley of Little Leading Creek, two miles north of Rutland, a lower coal, probably the Patriot lies at an altitude of 600 feet where it is mined on the Chase farm. A section of the coal furnished by a farmer is as follows:

	Ft.	In.
Coal	1	2
Shale	1	6
Coal	1	4

In places the shale parting disappears leaving 4 feet of coal.

At Langsville the Cambridge limestone is at an elevation of 580 feet, and the K. & M. R. R. is tunneling at this horizon. The Pomeroy coal in the hills north of Langsville is usually less than 30 inches thick.

At Rutland the interval between the Ames limestone and the Pomeroy coal is 151 feet, aneroid measurement. At the same place the white limestone beneath the Pomeroy coal attains a thickness of over 18 inches. Between Pomeroy and Rutland no limestone was observed at all, and it is apparent that in this locality the rock is not abundant.

In the southwestern part of the township the dip of the strata is in places over 33 feet per mile to the southeast.

Sutton Township. The Pomeroy or 8a coal is everywhere below drainage in this township except in the southwestern part in the valley of the Ohio River and a tributary stream.

Section 33 shows this seam as found in the mine of W. F. Bartels at Syracuse.

The impure coal at the top is sometimes marketed and at other times rejected. Streaks of pyrites were found at 12 and 21 inches above the bottom of the seam. The fuel is marketed locally and also shipped by rail. The seam lies 80 feet below the valley of the river and is reached by a slope.

Chemical analysis and calorific value of Section 33:

Ultimate.		*Proximate.*	
Carbon	65.29	Moisture	4.85(a)
Hydrogen	5.32	Volatile Matter	36.28
Oxygen	12.76	Fixed carbon	46.35
Nitrogen	1.17	Ash	12.52
Sulphur	2.94		
Ash	12.52		
	100.00		100.00

Calorific value .... 6624 calories.

(a) Moisture in the air-dried sample about 4%.

SECTION 33

	Ft.	In.
7. Pomeroy sandstone, unmeasured,		
6. Impure coal,	0	7½
5. Horn coal,	0	5½
4. Coal,	1	4
3. Horn coal,	0	2½
2. Coal,	2	3½
1. Clay, unmeasured,		

The sample included the entire section, though the upper 7½ inches are sometimes rejected in shipment.

Salem Township. The Pomeroy coal in this township lies at an altitude of from 850 to 950 feet and is limited to a few hills in the three southeastern sections. The thickness of the coal is nowhere reported to be over 30 inches.

Near Hanesville at the township line, the following section was measured.

Top of hill.	Ft.	In.
Sandstone, soft, coarse	18	0
Shale	5	0
Coal, Pomeroy	1	8
Shale, with limestone nodules partly covered	25	0
Clay, red	11	0
Sandstone	4	0
Shale, red	31	0
Shale with limestone	2	6
Shale, sandy	8	0
Clay, red with nodular ore and limestone	35	0
Shale, gray	5	0
Sandstone	3	6
Shale, partly covered	14	0
Ames limestone, impure	1	6
Shale calcareous	34	0
Limestone with red cherty iron ore	2	0
Sandstone	4	0
Clay, red (partly covered)	13	0

	Ft.	In.
Sandstone, shaly	22	0
Cambridge limestone	2	1
Coal, impure	2	0
Shale	12	0

The Ames limestone is impure and has few fossils. The coal below the Cambridge limestone in places reaches 30 inches in thickness but is usually very impure.

In sections 6 and 12 the strata in the high ridge show an anticlinal structure, the axis of which appears to run very nearly north and south.

Scipio Township. This lies west of Bedford and contains both the Pittsburg and Pomeroy seams, the interval between the two ranging from 14 to 20 feet. The Pittsburg is the important seam in the northern half of the township, but it thins to the south where the Pomeroy becomes the thicker seam.

Near Downington P. O. the two coals were found as follows:

Sandstone, unmeasured.	Ft.	In.
Pomeroy coal No. 8a	1	8
Calcareous shales	15	0
Pittsburg coal, No. 8	3	0
Shales	15	0

In the northern part of the township the Pomeroy coal is usually less than 20 inches thick, but in the southeastern part it varies from 24 to 30 inches. It scarcely needs be said that the seam in this township is of little importance.

Bedford Township. The Pomeroy coal is quite uniform throughout this township both as to thickness and also with reference to the interval between it and the Pittsburg coal. The thickness of the Pomeroy seam is usually about 20 inches and the interval between the coals 20 feet. The Pomeroy coal is seldom mined except where conditions are favorable for stripping.

On the Mayhugh farm, in section 21, the Pomeroy coal is as follows:

	Ft.	In.
Coal	0	8
Shale	0	10
Coal	1	8

The Pittsburg or No. 8 coal outcrops about 20 feet below.

The following section shows the remnant of the Pomeroy coal in the northwest corner of section 12.

	Ft.	In.
Sandstone	25	0
Shale	4	6
Coal	0	1
Shale	0	3
Coal	0	3
Shale	7	0

Near the eastern edge of section 20 the two coals were found as follows:

	Ft.	In.
Sandstone	4+	
Shales	2	0
Pomeroy coal, No. 8a	1	6
Shales, blue	8	0
Shales with nodular limestone	11	0
Shaly sandstone	9	0
Pittsburg coal, No. 8	2	6+

This section shows an interval of 28 feet between the two coals. rather large for this territory.

THE POMEROY COAL IN ATHENS COUNTY.

While the Pomeroy coal is occasionally seen in the hills along or near the south bank of the Hocking River, it is little more than a streak until Alexander and Lodi townships are reached. Even there it is of little importance.

Alexander Township. The Pomeroy coal, like the Pittsburg, is rather uncertain and variable in this township. However, a blossom of the seam may nearly always be found where due while the Pittsburg coal may occasionally disappear entirely. The interval between the two coals is usually 20 feet which consists of shales often containing much white limestone. The Pomeroy coal is usually too thin to be of any importance but the Pittsburg coal is in places 4 feet thick.

Lodi Township. The Pomeroy coal is from 12 to 18 inches thick in this township and is often underlain with several feet of white limestone whieh is very useful for road building.

Near the south edge of section 16, the following measurement was taken along a stream:

Shale, sandy, unmeasured.	Ft.	In.
Shale, dark	7	0
Coal	1	6
Shale, dark	1	6
Limestone	5+	

The Pomeroy sandstone is nearly always present.

The downstream limit of outcrop of the Pomeroy coal on the Middle Branch of Shade River is in section 1. A thickness of 18 inches is reported where the coal has been stripped in this part of the township.

THE POMEROY COAL IN GALLIA COUNTY.

The seam is usually found in this county wherever due but sometimes it is little more than a prominent streak. Generally, however, it is of workable thickness.

Along the Ohio River in the western half of the county the lower or Pittsburg coal is usually the most prominent. Farther west this seam thins and rapidly disappears. Occasionally the two coals are of workable thickness in the same hill, as near Mercerville.

The structure of the Pomeroy seam in this county is very simple. Occasionally it consists of a solid block, that is without partings, but quite often it has a thin parting near the middle.

The roof is similar to that at Pomeroy and vicinity. Sometimes the sandstone rests directly on the coal but at other places the two are separated by a bed of shales.

While the seam in this county will never be the source of a large production of coal, it will long continue to yield an adequate supply for the citizens.

Cheshire Township. This township contains much valuable coal and several new mines are preparing to begin operating.

In the southwestern quarter of the township the coal is well up in the ridges but has a good thickness and is mined in a small way on nearly every farm. Some of the coal is hauled to Bidwell in Springfield township.

In the I. N. Smith bank, near the center of section 26, the structure of the coal is as follows:

	Ft.	In.
Shales, bluish, unmeasured.		
Coal	1	5
Clay streak		
Coal	0	3
Horn coal	0	1½
Coal	1	9
Fire clay, unmeasured.		

The coal is unusually hard and rather flinty. It has a firm shale roof.

In the Halfhill bank, near the western edge of section 21, the following section was taken:

	Ft.	In.
Shales, unmeasured.		
Coal	0	6
Shales	0	4
Coal	1	4
Shaly streak		
Coal	1	8
Pyrites band	0	1
Coal	0	6
Clay	0	5½
Coal	0	2½
Fire clay, unmeasured.		

This section is typical of the coal through the greater part of the township.

In the mine of the Minshall Coal Company at Carlton the coal was found as represented in Section 34.

SECTION 34

		Ft.	In.
9.	Shale, unmeasured,		
8.	Coal,	0	3
7.	Parting,	0	3/8
6.	Coal,	0	2
5.	Parting,	0	1/4
4.	Coal,	0	2
3.	Parting,	0	5/8
2	Coal,	3	6
1.	Clay, unmeasured,		

Chemical analysis and calorific value of section 34:

Ultimate.		*Proximate:*	
Carbon	62.95	Moisture	8.21(a)
Hydrogen	5.48	Volatile Matter	34.23
Oxygen	16.91	Fixed carbon	46.10
Nitrogen	1.02	Ash	11.46
Sulphur	2.18		
Ash	11.46		
	100.00		100.00

Calorific value.......................................6387 calories.

(a) Moisture in the air-dried sample about 4%.

The sample included everything shown in the section except parts 1, 3 and 9.

Near the southern edge of the township, the coal is less thick than the normal and continues thinning to the south into Addison township. In the Matthews bank near the center of section 13, the coal has an altitude of 725 feet and a thickness of 38 inches with two shale and pyrites streaks.

At Kyger in the eastern part of the township the Pomeroy coal is underlain by a 20-inch bed of white limestone.

Morgan Township. The Pomeroy coal is confined to the eastern row of sections in this township and lies at an altitude of nearly 900 feet.

It is workable in sections 2 and 3 and is mined in a small way by the farmers. A thickness of 4 feet is reported.

Springfield Township. A few hills in the eastern part of this township extend above the horizon of the Pomeroy coal but the seam is not found in workable thickness.

Addison Township. This small township has been eroded by a large preglacial stream making the area of the Pomeroy coal comparatively small.

Most of the coal of the township is less than 30 inches thick. South of Campaign Creek, a stream flowing southeast across the middle of the township, a thickness of 30 inches is unusual. In the northwestern part of the township in sections 35 and 36 considerable coal was formerly mined, a thickness of 36 inches being reported.

In section 36 the Ames limestone was found to be 167 feet below the Pomeroy coal by aneroid measurement. The limestone at this point is impure, ferruginous, and contains a few crinoids and numerous cephalopods.

The Pomeroy or 8a coal has been mined on the land of L. Davis in the southwest corner of section 19. The coal was found as follows:

	Ft.	In.
Sandstone, thin-bedded, over 4 feet.		
Shales	2	0
Coal	0	6
Shales	0	½
Coal	2	0

Gallipolis Township. Only the hill tops in this township contain coal, and that is the 8a or Pomeroy seam. The No. 8 or Pittsburg coal is occasionally represented by a black streak, but was nowhere found of workable thickness.

The Pomeroy coal is thin but has been mined at several places in this township both west and northeast of Gallipolis. However, the mines have been small and the quantity of coal removed unimportant. Along Paint Creek, west of Gallipolis, this seam lies 190 feet (aneroid measurement) above the Ames limestone.

Northeast of Gallipolis the area of the seam is larger, but the quantity of coal is small. Near the mouth of Mill Creek in section 23 the coal has been mined in a small way. A thickness of 30 inches is reported. In the same hill the following section was measured with the aneroid:

	Ft.	In.
Pomeroy sandstone	40	0
Pomeroy coal	2	6
Unseen	116	0
Coal blossom		
Blue nonfossiliferous limestone, quite persistent	1	8

The altitude of the Pomeroy coal is here 699 feet.

Green Township. The coal of this township is well up in the hills and lies in numerous small islands. Many country banks have been opened at various times, but very few continue in operation. A thickness of 2 feet is unusual and as the Pittsburg coal is available in parts of the township little attempt is made to work the Pomeroy seam.

Near Northup the interval between the Cambridge limestone and the Pittsburg coal was measured with a hand-level and found to be 230 feet. No trace of the Ames limestone was observed.

Walnut Township. There are a few outliers of the Pomeroy coal, which lie high in the hills, in the southeastern part of the township. The coal is seldom thick enough to be worked, and has very little cover.

Sand Fork, a tributary of Symmes Creek, has eroded its valley below the Cambridge limestone. The Ames limestone is probably absent as no trace of it was seen in the township. Likewise the Pittsburg coal is absent, no trace of it having been noted.

Ohio Township. The coal lies quite low in this township and the principal outcrop is along the Ohio Valley and Swan Creek. The Pomeroy coal is seldom mined except by stripping as the thickness is rarely over 18 inches. The Pittsburg coal lies about 30 feet below and has been mined in many places.

Clay Township. The conditions in Clay township are much the same as in Ohio township. The Pomeroy coal is usually present but is of little value owing to its thinness.

Perry Township. The Pomeroy coal is confined to two extremely high hills in the southeastern part of the township. The region all around has been much lowered by a large preglacial stream and by Symmes and Raccoon Creeks. It is remarkable that a hill of such height should be left. Popular Knob, the larger of the two hills has an altitude of 1025 feet. The Pomeroy coal has been mined in the hill and has an altitude of 950 feet. The Cambridge limestone, by aneroid measurement, lies 270 feet below the coal.

Harrison Township. About one-half of Harrison township is underlain with the Pomeroy coal. The western part, as a rule has a fair thickness, but toward the east the Pomeroy seam thins and the Pittsburg acquires a workable thickness. In the western half, scarcely a trace of the Pittsburg coal was seen.

In the western row of sections the Pomeroy coal has long been mined for local use. The seam is reported to be 3 or 4 feet thick with no partings.

In the eastern part of the township the Pomeroy coal lies from 30 to 35 feet above the Pittsburg seam and is seldom over 2 feet thick.

Guyan Township. The Pomeroy coal lies rather low in Guyan township and as a result outcrops only along the deeper valleys. Nearly every farm along Indian Guyan Creek and its tributaries has an open-

ing where coal has been taken out. The thickness ranges from 2 to 4 feet and is usually without any partings.

Near the head of Rocky Fork, northwest quarter of section 28 on the Clary farm, the coal is as follows:

	Ft.	In.
Black shales, unmeasured.		
Coal	3	6
Fire clay, unmeasured.		

The base of the coal has an altitude of 840 feet. In the same vicinity the following section was measured with the hand-level:

	Ft.	In.
Clay with limestone nodules	15	0
Clay, red	25	0
Shales, gray	10	0
Sandstone, coarse grained	20	0
Shales	20	0
Clay, red	25	0
Shales with nodular limestone	10	0
Sandstone, massive	40	0
Coal, Pomeroy or 8a	3	6
Partly covered, sandstone seen	27	0
Coal blossom, Pittsburg or No. 8		
Shales, calcareous	25	0
Sandstones, massive	15	0
Bed of stream.		

For a distance of two miles east from where the above section was taken the dip of the Pomeroy coal was found to be 40 feet per mile.

The coal has a thickness of 4 feet on the Houck farm in section 35.

In the Belleville bank, section 27, the following measurement was made:

	Ft.	In.
Sandstone	15	0
Shales, gray	4	0
Shales, dark	10	0
Coal	0	6
Shales	1	6
Coal	3	0
Fire clay.		

The Pittsburg coal is not mined anywhere in the township, and so far as has been demonstrated it is usually thin or entirely wanting.

THE POMEROY COAL IN LAWRENCE COUNTY.

The Pomeroy coal is found in several townships in the eastern part of the county where it forms the well-known "Greasy Ridge" seam. The coal lies near the tops of the hills and the area is small.

In structure the seam is similar to that in Gallia county, consisting at times of a solid block of coal and occasionally of coal with one or more thin partings. The Pittsburg seam is never represented by more than a streak.

Mason Township. The surface of this township is mostly highland. The western portion is drained by Symmes Creek, and Sand Fork a tributary of the former heads in the southeastern part and flows north. The Pomeroy coal is an important local source of fuel. The coal is present in the higher hills along Sand Fork and in the dividing ridge between that stream and Symmes Creek. The Pittsburg coal is not workable in any part and is usually entirely wanting.

In the northeast corner of section 16, the Pomeroy coal has long been mined by the farmers. In the Massie bank, the structure is as follows:

	Ft.	In.
Sandstone	10+	
Coal	5	0
Shales, unmeasured.		

The above section shows the typical structure of the coal. The thickness is somewhat above the average but the solid seam with no partings is quite characteristic of the Pomeroy coal in Gallia and Lawrence counties.

In the Watson bank, southeast corner of section 24, the structure of the Pomeroy coal is as follows:

Sandstone, massive, unmeasured.	Ft.	In.
Shales	5	0
Coal	1	10
Shales	1	10
Coal	4	0
Shales	0	8
Coal	0	3
Fire clay, unmeasured.		

The base of the coal in the Watson bank has an altitude of 860 feet. The partings in the coal at this point are very similar to those found in the Pomeroy coal in Rutland township, Meigs county.

The following section was taken in the northwestern quarter of section 25:

	Ft.	In.
Sandstone	25+	
Shales	11	0
Coal, Pomeroy	4	0
Fire clay	2	0
Limestone	1	0
Shales	19	0
Coal blossom, Pittsburg	0	6
Fire clay	1	0
Sandstone, unmeasured.		

Windsor Township. The eastern and western parts of this township are deeply eroded by Indian Guyan and Symmes Creeks respectively. The Pomeroy coal is confined to the highlands between the two streams and a few outliers east of Indian Guyan Creek. The ridge running north and south between Indian Guyan and Symmes Creeks is known locally as Greasy Ridge, and the Pomeroy coal is there called the Greasy Ridge coal. This seam is mined in many places along the ridge and supplies the country for miles around.

The following section was taken in the Dillon bank near the center of section 4:

	Ft.	In.
Sandstone over 20 feet.		
Shales	3	0
Coal	3	10
Shales, unmeasured.		

In section 9 coal is mined on the Holderby and Capper farms. A thickness of 4 feet is reported. The altitude of the coal is there 917 feet.

The eastern row of sections contains the Pomeroy coal but with an inferior thickness.

In the southwestern corner of section 28, a 30 inch ledge of white limestone was seen at an altitude of 685 feet.

Rome Township. More than one-half of this township is underlain with the Pomeroy or 8a coal but the seam is usually too thin to be workable. The Pittsburg coal is nowhere present.

For many years the Pomeroy coal has been mined in a small way on the east side of Paddy Creek, one mile northeast of Labelle. In places the coal attains a thickess of 40 inches. There are no regular partings, but lenticular pyrite boulders, often having a diameter of 14 inches, abound in the body of the coal.

On Federal Creek in section 23, the coal attains a workable thickness. The Nichols farm in section 17 on the river front, has the Pomeroy coal with a thickness of 2 feet. The western row of sections contains only a moderate quantity of coal.

Union Township. The surface of this township is much lowered by the broad valleys of Symmes and Indian Guyan Creeks and their tributaries, therefore very little of the Pomeroy coal is left in the hills. West of Symmes Creek a workable thickness has not been found. As for the remainder of the township a thickness of 36 inches is unusual. The Pittsburg coal is wanting in all parts.

On the J. Suiter farm in section 23 the Pomeroy coal is only 24 inches thick. In section 2, on the Brammer farm, the seam has a thickness of 36 inches; however there is so little cover that the coal is much weathered. In sections 1, 12, 13 and 24 the quantity of Pomeroy coal is very moderate.

The Cambridge limestone is above drainage on Symmes Creek. The coal beneath the limestone is stripped in places for local use.

Fayette Township. The Pomeroy coal is limited to a few of the highest ridges in this township, and is not workable in any part. The Pittsburg coal is entirely wanting.

Throughout the greater part of the township the Cambridge limestone is above drainage. The following measurement was made in section 23:

	Ft.	In.
Shales, unmeasured.		
Cambridge limestone	1	6
Shales	1	0
Coal	0	10
Shales	5	0
Limestone, nonfossiliferous	1	0

The lower layer of limestone of the above section has been noticed as far north as Athens county.

In the following section which was measured with the hand level on the river bluffs at Burlington, the nature of the strata lying below the Ames limestone is shown:

	Ft.	In.
Ames limestone	2	9
Shales with limestone nodules	20	0
Coal	0	10
Shales	5	6
Coal	0	5
Shales with ferruginous limestone	7	0
Sandstone, thin-bedded	11	0
Unseen	13	0
Sandstone	1	6
Unseen	22	0
Sandstone	2	0
Shales	2	0
Sandstone	2	9
Shales	5	6
Coal, shaly	5	6
Sandstone, massive	63	0

The Ames limestone is impure and sandy but highly fossiliferous. The rocks for a distance of over 200 feet above this formation were well exposed, but no trace of the Pomeroy or Pittsburg coals was found.

CHAPTER III.

THE MEIGS CREEK COAL.[1]

This seam is regarded the equivalent of the Sewickley of Pennsylvania. It was named Meigs Creek by the late Professor C. N. Brown because that stream drains the central part of the territory.[2]

The position of the seam is usually from 80 to 100 feet above the Pittsburg. This has been made clear from the sections given in the chapters devoted to the Pittsburg coal and is further demonstrated in the pages which follow.

While the coal is due in the hills all the way from Jefferson to Lawrence counties, it is found in workable quantities only in Belmont, Harrison, Monroe, Washington, Noble and Morgan counties.

The coal lacks the persistence and regularity of its neighbor, the Pittsburg or No. 8 seam. Sometimes it is divided into two parts or benches by a prominent bed of shales or clay, but more often this structure is wanting. Sometimes the seam is without any parting, but usually one or more bands of shale, clay or pyrites is found. Both floor and roof are irregular, rising or dipping and thus modifying the thickness of the seam. Especially is this true of the roof which in a short space may occasionally entirely cut out the coal.

These features indicate that conditions were not uniform during the deposition of the coal and the rock which forms the roof. Probably these deposits were laid down in coastal swamps or marshes that were partly disconnected, the conditions of deposition being slightly different in the different basins.

The absence of the coal where due may be a result of water too deep to permit of the coal plants flourishing, or just the reverse, that the water was so shallow the vegetation after falling was not properly submerged. The latter appears more probable for with deeper waters marine fossils might be expected.

The quality of the coal is inferior to the Pittsburg, as the analyses will show. In spite of these disadvantages, however, the seam is an important one, and its value will increase as the great seam below is more and more worked out.

THE MEIGS CREEK COAL IN HARRISON COUNTY.

This seam is found in workable thickness and quantity in two townships only, Athens and Short Creek. However, it may occasionally

[1] For method of sampling see Chapter IX.

[2] Geol. Sur. of Ohio, Vol VI, p. 1059.

be seen in the highest hills in other townships and especially in the vicinity of Cadiz, where it is reported to have been formerly worked in a very small way. Its interest in that locality, however, is geological rather than commercial. The seam usually lies from 70 to 90 feet above the Pittsburg coal.

Athens Township. A large acreage of the Meigs Creek coal exists in this township. In the northwestern part it is found in the highest hills only, while in the eastern and southeastern parts it is much more extensive. The seam is everywhere above drainage in this township, has long been worked by the farmers and is an important source of fuel.

On land of Joshua Kirk, one mile west of New Athens, Section 35 of the coal was taken.

SECTION 35

	Ft.	In.
7. Shale, unmeasured,		
6. Coal,	0	11
5. Parting,	0	¼
4. Coal,	1	10
3. Parting,	0	¼
2. Coal,	1	5
1. Fire clay, unmeasured,		

Chemical analysis and calorific value of Section 35:

Ultimate.		*Proximate.*	
Carbon	68.67	Moisture	5.35(a)
Hydrogen	5.21	Volatile Matter	33.09
Oxygen	12.38	Fixed carbon	51.27
Nitrogen	1.25	Ash	10.29
Sulphur	2.20		
Ash	10.29		
	100.00		100.00

Calorific value .... 6885 calories.

(a) Moisture in the air-dried sample about 2%.

The sample included the entire section except parts 1 and 7.

The following section of the coal was measured in the Culbertson bank, south of the village, New Athens:

	Ft.	In.
Shale and impure coal	2	0
Soapstone	1	8
Bone coal. Rejected	0	2
Top coal	2	11
Shale	0	¼
Bottom coal	1	4
Soapstone	2	0

An average thickness of 4½ feet is claimed for the coal in this mine. Many lenticular nodules of pyrite are found, and are thrown out in mining. The bone coal and soapstone above are removed leaving the overlying shales and impure coal to form the roof. The bearing in is made between the Top and Bottom coals, and then the former is shot from above and the latter from below.

On an average four men are kept at work in this mine during the year, supplying the village New Athens and the neighboring farmers much of their fuel.

The Meigs Creek coal has been more extensively worked in this township than elsewhere in the county, scores of openings having been made, but few of these are kept in working order.

The coal does very well as a fuel for domestic purposes, but because of the large quantity of ashes resulting, some regard the Pittsburg coal as the more economic though it costs more per ton.

Short Creek Township. Small patches of the Meigs Creek coal are found in the hill-tops in the northern part of the township. To the south, however, it forms almost a continuous bed, being removed in the deeper valleys only. It is an important source of fuel to the farmers in this locality, since the Pittsburg seam is everywhere below drainage. The coal makes a hot fire, but is high in ash.

On the Lodge farm in section 16, the following measurement of the seam was made:

	Ft.	In.
Shales	3	0
Coal	2	9
Slate parting very thin, sometimes absent		
Coal	1	3

The thickness of the seam in this mine ranges from 3 ft. 8 in. to 4 ft. 6 in. The Meigs Creek coal in this township forms a valuable deposit of fuel which some day will be extensively mined. The Pittsburg seam, however, must be removed first.

Lying in the tops of the highest hills is found another seam, No. 10. It is reported to have formerly been worked in the hill at Harrisville. Its place is about 100 feet above the Meigs Creek coal.

THE MEIGS CREEK COAL IN BELMONT COUNTY.

This county contains a larger area of the Meigs Creek coal than any other county in the state. The seam is found in every township, but in those in the northwestern part it has been largely removed by erosion. Nowhere else in the state is the seam more regular and persistent. Even here, however, it varies considerably and sometimes thins to such an extent that it is not of workable thickness. This is true in part at least of Somerset and Colerain townships. Probably over parts of the territory in which the map shows the seam present it will be found wanting or of unworkable thickness. This condition results from the fact that over considerable areas the seam is below drainage and has not been mined, making accurate measurements of the coal impossible.

The seam lies from 60 to 100 feet above the Pittsburg coal and hence the two are found beneath nearly the same territory. The Pittsburg coal, however, is the thicker seam and is of superior quality. This fact will keep the Meigs Creek coal in place until the lower seam shows signs of exhaustion.

Flushing Township. This township is remarkable for having at the present time the one mine for railroad shipment of the Meigs Creek coal in Ohio. Shipment by rail is said to have begun as early as 1880. Mining is done by machinery, and the coal is hauled from the mine by electrical power.

The mine is located at the village Flushing and is operated by the Flushing Coal Company. Section 36 was taken in this mine.

SECTION 36

	Ft.	In.
3. Soapstone	1	4
2. Coal	3	12
1. Sandstone, unmeasured		

PLATE IV. Exterior Works of Flushing Coal Co., Flushing, Belmont Co. This is the only mine in Ohio from which the Meigs Creek Coal is shipped by rail.

The seam is known locally as the Four foot coal, but it does not average quite that thickness. Probably 3 feet 8 inches is nearer the correct measurement. Nodules of pyrites are common in the coal, and have to be thrown out by the miners. The fuel makes a hot fire but is high in ash—a condition that will retard its development.

Chemical analysis and calorific value of Section 36:

Ultimate.		*Proximate.*	
Carbon	66.31	Moisture	4.98(a)
Hydrogen	4.95	Volatile Matter	33.30
Oxygen	12.32	Fixed carbon	48.90
Nitrogen	1.19	Ash	12.82
Sulphur	2.41		
Ash	12.82		
	100.00		100.00

Calorific value .... 6652 calories.

(a) Moisture in the air-dried sample about 2%.

The sample included all of part 2 of the above section except about one inch of impure coal near the top. The sample measured about 5 inches in width and 2 inches in depth.

Among the places in this township where the coal has been worked in a small way by farmers may be mentioned: Northwest quarter, section 19, Joseph Bailey farm; Southwest quarter, section 25, Mahlon T. White farm; Northeast quarter, section 31, A. McElwain farm; Southeast quarter, section 33, L. M. Dunlap farm; Northwest quarter, section 27, Wilson farm; Southwest quarter, section 21, A. Barricklow farm; Northwest quarter, section 13, T. Conrow farm.

The average of the Meigs Creek coal in this township is small being in fact almost restricted to the high lands in the extreme eastern part which constitute the divide between the waters flowing into the Ohio and Muskingum Rivers.

The interval between the Pittsburg and Meigs Creek coals in this township varies considerably ranging from about 65 to 90 feet.

The hilltops in the eastern part of the township contain a higher seam. It lies from 100 to 110 feet above the Meigs Creek coal, but is nowhere worked. At Flushing this seam measures approximately two feet in thickness.

Wheeling Township. The Meigs Creek coal is found wherever due in this township. Near the western border the seam is just above drainage, but eastward it has been more extensively removed, the large streams deepening their channels more rapidly than the coal dips.

The seam has been worked in a small way at a number of places, but nowhere for railroad shipment. On the McCracken farm, northeast quarter section 20, the coal was found as shown in Section 36a.

According to the proprietor, the interval between the Pittsburg and Meigs Creek seams, as shown by the drill, is here 80 feet.

Chemical and calorific value of Section 36a:

Ultimate.		*Proximate.*	
Carbon	66.41	Moisture	7.52(a)(b)
Hydrogen	5.14	Volatile Matter	31.75
Oxygen	13.99	Fixed carbon	49.19
Nitrogen	1.11	Ash	11.24
Sulphur	2.11		
Ash	11.24		
	100.00		100.00

Calorific value....................6589 calories.

(a) Sample wet. Moisture probably 2% or 3% high on this account.

(b) Moisture in the air-dried sample about 2%.

The sample included the whole of the section except 7 inches at the bottom, which could not be reached on account of water standing in the mine.

The seam has also been worked on the Branson farm, northwest quarter, section 8; on the Beall and Lyell farms, southwest quarter, section 2; on the Caldwell farm, southeast quarter, section 1; on the Ritchey farm, southeast quarter, section 7; on the Grimes farm, southwest quarter, section 7; on the Walker farm, southwest quarter, section 3, and on the McCracken farm, northeast quarter of section 20.

In quality and thickness the coal is similar to the corresponding seam in Flushing township. The development of the Meigs Creek coal is retarded by the larger and better one, the Pittsburg or No. 8 coal, which is exposed along all the deeper valleys of the township.

The higher coal also is found in the hilltops over the entire township. Its place is about 100 feet above the Meigs Creek seam, but it is nowhere worked. The lower seams—Meigs Creek and Pittsburg—must be removed before this hilltop seam will become valuable.

Colerain Township. The Meigs Creek coal in this township is cut out in the deep valley of Wheeling Creek and along its principal tributaries. Elsewhere it is under cover except in the northeast corner where it is cut out along a stream in sections 9 and 15. The coal is thinner in this township than farther west. At Barton Station it measures 2 feet 3 inches. Eastward from this place it is still less important, and is probably nowhere of workable thickness. The seam is not mined anywhere in the township, though it is reported to have been formerly worked at Barton Station.

The following section was measured at Barton Station by Mr. J. E. Hyde:

	Ft.	In.
Shales with a few thin layers of sandstone	25	0
Uniontown coal	3	0

	Ft.	In.
Unseen	45	0
Sandstone, thin bedded	13	0
Limestone	10	8
Shales	3	0
Unseen	7	4
Limestone	3	0
Unseen	12	6
Shaly sandstone	3	5
Limestone and shales	19	2
Limestone	13	2
Limestone and shales	20	1
Shales	1	10
Meigs Creek coal	2	3
Shaly sandstone	5	2
Black shale	0	2
Coal	0	8
Shales and very thin limestone layers	4	0
Shales	5	2
Unseen	5	0
Limestone and shales	41	4
Unseen	25	0
Pittsburg coal, unmeasured.		

While the Meigs Creek coal diminishes in importance in this township, the higher seams become more valuable. The Unointown coal lies from 110-145 feet above the Meigs Creek, and is known locally as the "Three-Foot seam." It is worked in a very small way at a number of places, among which may be mentioned the Wise farm, northeast quarter of section 20. Another place is near the school house in the southwest quarter of the same section. The seam there measures 4 feet.

Lying about 100 feet higher than the Uniontown coal is found another seam in the hill tops of the eastern part of the township. This coal is sometimes called by the farmers, "The Upper Six-foot seam" and sometimes the "Cut seam" from its exposure in the cut on the Colerain pike at the top of the hill back of Martin's Ferry. The coal has been worked at Colerain, just below the greenhouse. It is of poor quality.

The Pittsburg coal underlies the township except where cut out by Wheeling Creek and to a small extent by its tributaries. It is extensively worked and is of great value.

Pease Township. The thinning of the Meigs Creek coal noted in Colerain township to the west, continues in Pease township where it is represented by a thin stratum two or three inches in thickness or wanting entirely, its place being taken by dark shales. It is not mined anywhere in the township.

The Uniontown or "Three-foot Seam" is mined at a number of places, among them the Helsey and Thomas farms in the southeast quarter of section 36, and the old Woods farm in the northeast quarter of section 35. On the latter farm a seam 2½ feet in thickness is found 40

feet below the Uniontown coal, and the same is true two miles farther north, only the interval there is smaller, being about 25 feet. and the lower coal much thinner.

The highest seam of all, known locally as the "Upper Six-foot" or "Cut seam," is found in the hill tops over the township. As previously stated it is of poor quality, a layer or two only near the top being good. The coal has been mined on the Owen Carr farm in the southeast quarter of section 35 where it is reported 6 feet in thickness. In the cut on the Colerain pike back of Martin's Ferry the seam measures 6 feet 5 inches.

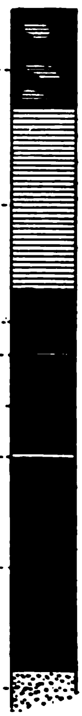
The Pittsburg coal underlies the township except where removed by erosion. It has long been mined on the river front for use in Martin's Ferry and Bridgeport. Occasionally it is hauled over trestles directly from the mines in the hill side to the large steel works, thus reducing the cost of fuel to a minimum.

Warren Township. The Meigs Creek coal underlies a large area in the southeastern part of Warren township. Elsewhere in the township the seam has been largely removed by stream erosion, and as a result is now found only in the ridges between the streams. In a few places the coal extends over the line into Guernsey county, but not in sufficient quantity to be of commercial importance.

The coal has long been mined in the vicinity of Barnesville where it is sometimes known as the Upper Barnesville seam. Section 37 was measured in the Malden mine, Barnesville.

SECTION 37

	Ft.	In.
8. Roof coal, (shale and coal,)	1	0
7. Shale and soapstone,	1	10
6. Coal,	0	7½
5. Pyrites parting,		$\frac{1}{16}$
4. Coal,	0	11½
3. Black shale,	0	¼
2. Coal,	2	1½
1. Soapstone, unmeasured,		



The seam in this bank ranges from 3 feet 8 inches to 4 feet 3 inches in thickness. Thin partings of shale or pyrites are common, but usually these are local. In other words, they are not persistent as in the Pittsburg seam. The coal is marketed in Barnesville where it is regarded as a fuel for grates.

Chemical analysis and calorific value of Section 37:

Ultimate.		*Proximate.*	
Carbon	65.83	Moisture	4.47(a)
Hydrogen	4.99	Volatile Matter	35.31
Oxygen	11.71	Fixed carbon	47.15
Nitrogen	1.13	Ash	13.07
Sulphur	3.27		
Ash	13.07		
	100.00		100.00

Calorific value..6668 calories.

(a) Moisture in the air-dried sample about 2%.

Parts 1, 7 and 8 of the section were excluded in sampling. The sample measured 6 by 3 inches.

Here as elsewhere in the county the seam has the disadvantage of having to compete with the Pittsburg coal which is thicker and of superior quality. As long as this seam remains, the Meigs Creek coal will continue to be mined in the small way only.

Kirkwood Township. The Meigs Creek coal is found in the hills in the southern part of this township. The area, however, is small, and the seam nowhere worked.

Somerset Township. Nearly the whole of this township is underlain with the Meigs Creek coal. Very few exposures of the seam are found, however, owing to its being so generally below drainage.

In the extreme northeast corner of the township, on the Starbuck farm, section 6, a bank was opened a few years ago. The writer was not able to enter the mine, but learned that the coal measures about 4 feet in thickness.

On the western side of the township the coal has been mined near Temperanceville on the Austin Gallaher farm in section 33. The seam is reported to be 2½ feet thick and to contain many impurities.

The coal has been mined in a very small way at a number of places in the southwestern corner of the township, especially along the stream which heads near Boston (Atlas P. O.) and flows southwest into Monroe county. On the Shuman farm, northwest quarter, section 25, the following section of the coal was furnished by the proprietor:

	Ft.	In.
Soapstone	0	6
Coal	1	6
Soapstone	0	2
Coal	0	10

The coal is reported to vary in this locality from 2½ to 4 feet in thickness, and to be very impure.

In the valley of Captina Creek at Somerton several test wells for coal have been drilled. One found the Meigs Creek coal at a reported depth of 90 feet and another at 93 feet. The seam is said to be about 4 feet in thickness. The Pittsburg or No. 8 seam lies about 72 feet below the Meigs Creek, and is reported to be 4 feet 10 inches thick.

A higher coal known as the "Hill or Three-foot seam" has been mined at a number of places in the southern part of this township. On the Yocum farm, just south of Somerton, this coal formerly supplied the village grist mill with fuel. The mine is said to have been abandoned because of trouble from water.

Usually this seam is less than 3 feet in thickness and sometimes almost disappears. It is of poor quality.

Practically speaking this entire township is underlaid with the Pittsburg coal which as yet has scarcely been touched. The same is almost equally true of the next higher seam, the Meigs Creek. The "Hill or Three-foot" seam is smaller in area and otherwise inferior. Obviously this township contains a very large quantity of fuel.

Union Township. The Meigs Creek coal underlies the greater part of this township. In the deep valleys in the western and northeastern parts, however, the coal has been removed.

While the coal is not mined in the large way anywhere in the township, it is opened at several places by farmers who rely on it in part for their fuel.

Section 38 represents the coal in the mine of William Lodge at Lafferty.

Chemical analysis and calorific value of Section 38:

Ultimate.		*Proximate.*	
Carbon	68.32	Moisture	4.31(a)
Hydrogen	5.09	Volatile Matter	32.47
Oxygen	11.86	Fixed carbon	51.54
Nitrogen	1.11	Ash	11.68
Sulphur	1.94		
Ash	11.68		
	100.00		100.00

Calorific value..6837 calories.

(a) Moisture in the air-dried sample about 2%.

The sample included the entire section except parts 1, 7 and 8.

In the mine of J. S. Calbert in the southeast quarter of section 25 the coal was found as shown in Section 39.

The coal is quite irregular in thickness. Occasionally it is much reduced by "horse backs" of sandstone and at other times by broad

SECTION 38

	Ft.	In.
8. Impure coal,	0	4
7. Soapstone,	1	3
6. Coal,	1	1½
5. Parting,		⅜
4. Coal,	1	2½
3. Parting,	0	¼
2. Coal,	1	9½
1. Clay,		

SECTION 39

	Ft.	In.
7. Soapstone,	1	6
6. Pyrites,	0	⅛
5. Bone coal,	0	2
4. Coal,	0	7
3. Pyrites,	0	¼
2. Coal,	3	9
1. Shale, unmeasured,		

rolls in the floor. The position of the roof too, shows sudden changes, often varying several inches in 2 or 3 feet.

The coal is hard and bright but with occasional streaks of bone coal and shale, the latter of paper like thinness. It is unusually free from pyrites layers or nodules. This mine supplies in part the surrounding country and also the mills at Morristown, Belmont and Bethesda.

Chemical analysis and calorific value of Section 39:

Ultimate.		*Proximate.*	
Carbon	69.90	Moisture	4.17(a)
Hydrogen	4.97	Volatile Matter	35.09
Oxygen	11.33	Fixed carbon	51.14
Nitrogen	1.09	Ash	9.60
Sulphur	3.11		
Ash	9.60		
	100.00		100.00

Calorific value..7001 calories.

(a) Moisture in the air-dried sample about 2%.

The sample included parts 2, 3 and 4 of the section, and was cut from a face less than a day old. The sample measured 4 by 2 inches.

The Meigs Creek coal is mined on the John Gilliam farm in the southwest quarter of section 22, and also on the William Dunbar farm in the northwest quarter of section 6. The following measurement of the seam was made in the Dunbar mine:

	Ft.	In.
Shale	0	6
Soapstone	1	8
Coal	0	9
Soft shale	0	½
Coal	4	1
Shale, unmeasured.		

The coal is quite free from impurities. The soapstone above the coal is taken down in the rooms leaving the shale to form the roof. It serves this purpose well. In the entries the soapstone is not usually removed.

The Pittsburg or No. 8 coal underlies practically the entire township. It is worked in a small way at a number of places in the western part of the township where the coal outcrops and is the principal reliance of the citizens for fuel. The interval between the Meigs Creek and Pittsburg seams in the vicinity of Morristown is about 85 feet.

In the southeastern part of the township two seams higher than the Meigs Creek are found. Both are occasionally worked on a small scale by the farmers. On the J. W. Bentley farm in the southeastern corner of section 1, the lower of the two higher seams referred to has been mined by stripping in the bed of the creek. The exposure did not admit of measurement when visited by the writer, but the proprietor reported the thickness to vary from 2 to 3½ feet with an average of about

3 feet. This seam is reported, on evidence of a deep well, to lie about 190 feet above the Pittsburg coal, and approximately 100 feet above the Meigs Creek seam.

On the J. P. Owens farm, which joins the Ramsey referred to in the preceding paragraph, a seam is mined that lies about 50 feet higher than the one stripped on the Ramsey farm. This seam is small and unimportant.

Richland Township. This, the largest township in the county, contains a great quantity of mineral wealth.

Th Meigs Creek coal outcrops in valleys in the northern and southeastern parts of the township, but is elsewhere deeply buried. In the northwestern part of the township the seam has been worked on the Mitchener Heirs and George farms, both in section 12. The seam has also been mined in the bed of the creek in sections 12 and 18.

Along Wheeling Creek and tributaries in the northeastern part of the township the coal outcrops, but little attention is paid to it owing to the presence of the Pittsburg seam.

In the southeastern part of the township the coal outcrops in the valleys traversed by the Baltimore and Ohio railroad, and the St. Clairsville branch of this road. The seam has been mined on the Cunningham farm in the southeast quarter of section 32. It is now worked in a small way at several places between Neff's Station and Glencoe. The seam is finely shown in the railroad cut at Glencoe, being there about 4 feet thick and approximately 85 feet above the Pittsburg coal.

A higher seam than the Meigs Creek is worked in a very small way at a number of places in the township, especially in the hilltops near St. Clairsville. The seam is thin and at present of little value.

The Pittsburg coal underlies practically the entire township, being in fact removed by erosion only along Wheeling Creek in the extreme northeast corner of the township.

Pultney Township. The Meigs Creek coal underlies a large part of this township. It has been removed in the valley of McMahon's Creek and its principal tributaries, and of course in the valley of the Ohio River.

The coal has been mined in the hills facing the river just south of Bellaire. It is now mined on Brook's Run in the southeast corner of section 5 where it measures about 4 feet in thickness and is only 65 feet above the Pittsburg seam. The coal is mined also on the Giffen farm in the northeast quarter of section 7.

No extensive development of the Meigs Creek coal in this township needs be expected as long as large areas of the Pittsburg seam remain.

Goshen Township. The Meigs Creek coal underlies the whole of this township except along the streams in the northwest and southwest corners. Mines have been opened on several farms in the former area, but these have nearly all been abandoned.

At the Statler mine in the southeast quarter of section 31, the coal was found as shown in Section 40.

SECTION 40

	Ft.	In.
6. Soapstone,		
5. Bone coal,	0	1
4. Coal,	2	7½
3. Shale, and coal,	0	4
2. Coal,	1	5
1. Sandstone,		

Sometimes the seam measures 5 feet in thickness. Occasionally it disappears entirely, the soapstone roof cutting out the coal. It contains considerable iron pyrites.

Chemical analysis and calorific value of Section 40:

Ultimate.		*Proximate.*	
Carbon	64.77	Moisture	3.40(a)
Hydrogen	4.86	Volatile Matter	35.72
Oxygen	9.96	Fixed carbon	45.94
Nitrogen	1.08	Ash	14.94
Sulphur	4.39		
Ash	14.94		
	100.00		100.00

Calorific value .... 6578 calories.

(a) Moisture in the air-dried sample about 2%.

The sample included parts 2 and 4 of the above section, and was cut from a dry face that had been exposed less than two weeks. The sample measured 6 by 4 inches.

Near Belmont a higher seam is occasionally mined by the farmers, the coal being known as the Belmont. It is doubtless to be correlated with one of the higher seams mentioned in the discussion of Union township, which joins Goshen on the north.

Smith Township. The Meigs Creek coal is everywhere below drainage in the township except in the northeast part where it is cut out by

McMahon's Creek and one of its tributaries. On the land of Rev. Thomas H. Armstrong the coal was found as represented in Section 41.

SECTION 41

	Ft.	In.
8. Shale,		
7. Coal, not mined,	0	6
6. Coal,	1	9½
5. Shale,	0	⅜
4. Coal,	0	6
3. Shale,	0	¼
2. Coal,	1	0
1. Coal with pyrites,	0	½

The coal varies considerably in thickness owing to rolls in the floor. Numerous thin layers of shale and pyrites are found. These are not continuous but appear and disappear with frequency. The coal has a market among the surrounding farmers and in the village Glencoe.

Chemical analysis and calorific value of Section 41:

Ultimate.		*Proximate.*	
Carbon	67.36	Moisture	3.52(a)
Hydrogen	5.02	Volatile Matter	34.74
Oxygen	11.06	Fixed carbon	49.90
Nitrogen	1.05	Ash	11.84
Sulphur	3.67		
Ash	11.84		
	100.00		100.00

Calorific value .... 6884 calories.

(a) Moisture in the air-dried sample about 2%.

This sample included the whole of the above section except parts 1 and 8. The face from which the sample was cut, except part 7, had been exposed only a day or two. Part 7 had been exposed perhaps three months, but did not appear weathered in any way.

Mead Township. The Meigs Creek coal underlies the whole of this township except the eastern part where it is cut out by the Ohio River and several of its tributaries.

The seam has been mined by farmers in the valley of Pipe Creek as far up as Businessburg, just beyond which the coal goes under cover. The seam would be more largely worked in this vicinity were it not for the competition of the Pittsburg coal which is mined on the Berry farm

in the southeast quarter of section 18, and also at Dille's Bottom where Pipe Creek empties into the Ohio River. The Pittsburg seam is said to lie in the bed of the river at this place.

The Meigs Creek coal is exposed in the valley of Wegee Creek as far as the middle of section 2 where the seam goes under cover. The following section of the coal was made in this valley at the McMillen bank in the northwest quarter of section 32:

	Ft.	In.
Soapstone	3	0
Roof coal, not mined	0	4
Coal	4	5
Shales, unmeasured.		

No regular shale or clay partings are found in the coal, but irregular streaks of this material occur. The mine is worked on a small scale only.

A higher seam is mined on the Reiff farm in the southwest quarter of section 19. Its thickness is reported to vary from 18 inches to 3 feet. This seam lies about 160 feet above the Meigs Creek coal.

Wayne Township. The Meigs Creek coal is exposed in the valley of Captina Creek and its principal tributaries as far east as the Evans farm in section 10. There it dips below the creek, reappearing in the valley of the same stream about two miles west of Armstrong's Mills.

In the northwest corner of the township the coal has been opened on a number of farms, and is reported about 4 feet thick. Farther down Captina Creek the coal has been stripped in the bed of the stream.

The Pittsburg coal is nowhere above drainage in this township. This condition favors the mining of the Meigs Creek coal, but notwithstanding this the quantity of mining done in this township is small. The farmers seem to prefer hauling their fuel from Barnesville or Armstrong's Mills to the trouble of keeping a mine in order.

Washington Township. The Meigs Creek coal is below drainage in the western part of the township. It appears in the bed of Captina Creek on the Danford farm, near the junction of sections 16 and 22, and is above drainage farther down the valley.

The coal is reported to have been mined for half a century in a small way in the vicinity of Armstrong's Mills. Below is a section of the Hoover mine at that place. The section was furnished by the proprietor, the mine not being in a condition to be entered:

	Ft.	In.
Soapstone	1	4
Coal	1	8
Soft shales	0	2
Coal	1	8
Shales, unmeasured.		

The seam is said to average about 3½ feet in thickness in this locality, the extremes given being 2 and 4½ feet. Occasionally the roof dips causing a thinning of the seam.

The Pittsburg coal is mined for local use and railroad shipment at Armstrong's Mills. The seam is reached by a shaft the distance to the bottom of the coal being 69 feet.

On the hills along the western line of the township a higher seam appears. It is occasionally mined by farmers.

York Township. The Meigs Creek coal has been more extensively removed by erosion in this township than elsewhere in the southern part of the county. The seam outcrops in the valley of Captina Creek and its tributaries, and of course in the valley of the Ohio River.

Usually in the valley of Captina the coal lies a few feet only above drainage, but near Steinersville in the eastern part of the township, a marked anticline exists which brings the Pittsburg seam up to or slightly above water level. Here the Meigs Creek coal is well above drainage. This seam is now worked on the Korner farm in the northwest quarter of section 8.

The coal was formerly mined on the Ramsey farm at the west edge of Powhatton. It is found in the bed of the Ohio River about one and one-half miles south of the Belmont county line, where it has occasionally been mined by stripping during low water stages.

In the northeast corner of the township the coal is well shown along a railroad cut in the hills facing the river. About 15 feet below it another seam exists. The latter is about 4 feet in thickness, but of poor quality.

The Pittsburg coal is mined in a small way on the Schnegg farm in the northwest quarter of section 19. Formerly this coal was mined on the Owing and Ring farms in the southwest quarter of section 14. It has also been stripped in the bed of Captina Creek near the middle of the township.

THE MEIGS CREEK COAL IN JEFFERSON COUNTY.

This coal is nowhere mined in Jefferson county. It is doubtful if the seam is of workable thickness anywhere in the county. If so it is in Mt. Pleasant township into which the seam may extend from Short Creek township, Harrison county on the west and from Colerain township, Belmont county on the south. As stated elsewhere, however, the seam thins in Colerain township and hence the extension from that locality is unimportant. The coal is thicker in Short Creek township and probably extends into the western part of Mt. Pleasant township as a workable seam. No measurement of the seam was made for the reason that no suitable exposure of the coal was found.

The report on this seam elsewhere in the county is still less favorable. In Warren township, lying east of Mt. Pleasant, the seam is due, but is represented by a black streak only. Much the same condition prevails in Smithfield, Wells, Cross Creek and Wayne townships. In

none of these does the Meigs Creek coal exceed a few inches in thickness, and often it is represented by a thin streak and occasionally even that may be wanting.

THE MEIGS CREEK COAL IN NOBLE COUNTY.

The Meigs Creek coal is found in every township in the county with the possible exception of Buffalo. Duck Creek which crosses the county north to south in a deep and rather wide valley divides the coal into two areas, an eastern and western one.

The coal area west of Duck Creek is extensive, usually lies low in the hills and is exposed for the most part in the deeper valleys only. East of Duck Creek the coal lies high in the hills and hence is found beneath a relatively small part of the territory.

Nowhere is the coal mined for railroad shipment, but it is worked at many places for a local market. The supply for this purpose is adequate and will last for an indefinite period.

This seam was mapped and studied by Professor C. N. Brown and his report may be found in Volume V., Geological Survey of Ohio, published in 1884. Conditions in the territory have not changed materially since that report appeared, but since it is now out of print it is deemed advisable to review the essential facts here.

Beaver Township. This lies in the extreme northeastern corner of the county. The place of the coal is high in the hills and hence it is due in only a relatively small part of the township. It is not, however, always present in workable thickness where due. Thus in the southeastern quarter of the township the coal does not appear to be anywhere of mining thickness, but farther west the seam is an important source of fuel for the farmers.

In the southeast quarter of section 17 Professor Brown found the coal as follows:[1]

Sandstone, massive.	Ft.	In.
Shales	1	6
Coal	1	4
Clay	1	4
Shales	0	2
Coal	2	6
Clay	0	2
Coal	2	0
Clay	2	0
Limestone, unmeasured.		

Sections taken elsewhere in the township show a similar structure and thickness. Obviously one of the disadvantages of this seam is the numerous partings which make the coal dirty and increase the expense of mining.

The Pittsburg or No. 8 coal is at present mined in sections 5 and 11.

[1] Vol. V., p. 1082.

It appears to be present where due in workable thickness in the northeast quarter of the township, but farther west and south is wanting. The limestones lying below the coal are present, serving to locate the place of the seam.

Marion Township. This township lies south of Beaver. Its topography is very rough and the tops of the high ridges are well above the coal. Country banks are numerous, especially south and west of Summerfield. The coal mined, however, does not meet the demand, for much is hauled from the Stafford field in Elk township.

Section 42 was obtained in a mine on the C. T. Hague farm in the southeast quarter of section 12, about one and one-half miles northwest of Summerfield.

SECTION 42

	Ft.	In.
7. Coal,	0	9¼
6. Shale,	0	¼
5. Coal,	1	11
4. Shaly pyrites,	0	½
3. Coal with 3 pyrites streaks,	1	1
2. Coal,	0	2
1. Coal, impure not mined,	0	6

In thickness the coal varies from 4 feet 3 inches to 4 feet 9 inches. Overlying the coal is a bed of soapstone whose thickness is reported to range from 8 to 16 inches. Above the soapstone is the roof coal whose thickness is said to vary from 8 to 12 inches. Rarely is it wanting. The roof is quite strong, permitting the shooting of the coal. Concretions of pyrites are abundant near the base of the coal but less common higher in the seam.

Chemical analysis and calorific value of Section 42:

Ultimate.		*Proximate.*	
Carbon	65.61	Moisture	3.12(a)
Hydrogen	5.09	Volatile Matter	37.36
Oxygen	9.93	Fixed carbon	46.67
Nitrogen	0.92	Ash	12.85
Sulphur	5.60		
Ash	12.85		
	100.00		100.00

Calorific value..6739 calories.

(a) Moisture in the air-dried sample about 2%.

The sample included the entire section except parts 1 and 2, and measured 3 by 1½ inches. It was cut from a face that had been exposed about two weeks.

Sections taken elsewhere in the township show the same general structure, though the individual members vary in thickness.

In the ridge extending north from Summerfield the coal is thin or wanting.

Stock Township. The East Fork of Duck Creek crosses this township in almost a diagonal way in a deep narrow valley along which and its tributaries the Meigs Creek coal is exposed and frequently mined. It lies well up in the hills.

The coal ranges in thickness from 3½ to 5 feet with perhaps an average of 4 feet.

Section 43 was taken on the farm of Uriah Cleary, northwest quarter section 25.

SECTION 43

		Ft.	In.
7. Soapstone, unmeasured,			
6. Coal, with 2 thin partings of pyrites,		0	9½
5. Parting,	Smut band,	0	⅛
	Coal,	0	⅜
	Smut band,	0	⅜
4. Coal with a thin layer of pyrites,		1	7
3. Bone coal, rejected,		0	1¼
2. Coal,		1	3½
1. Coal, impure,		0	3

This mine has been in operation several years, the output being consumed by farmers and neighboring villages. The coal is quite hard and averages about 4 feet in thickness with a maximum of 5 feet. Rolls in the floor are not uncommon and where present reduce the thickness of the seam. Pyrites concretions from one to four inches in thickness and sometimes 3 feet in length are abundant.

Overlying the coal is a bed of soapstone reported to vary from 1½ to 2 feet in thickness, and above this the roof coal which is said to range from 2 to 2½ feet and to be more shaly than the coal below.

Chemical analysis and calorific value of Section 43:

Ultimate.		*Proximate.*	
Carbon	67.50	Moisture	2.55(a)
Hydrogen	5.11	Volatile Matter	38.40
Oxygen	9.27	Fixed carbon	47.64
Nitrogen	0.92	Ash	11.41
Sulphur	5.79		
Ash	11.41		
	100.00		100.00

Calorific value .... 6,952 calories.

(a) Moisture in the air-dried sample about 2%.

The sample included the entire section except parts 1, 3 and 7, and measured 3 by 1½ inches. It was cut from a face that had been exposed less than one day, but was not over 50 feet from the outcrop.

While the township will probably never be a large shipper of coal, it contains an adequate supply for home consumption.

Elk Township. The topography of this township is similar to that of Stock. East Fork of Duck Creek crosses the county in a broad curve from the northwest to the southwest, along which the coal is everywhere exposed.

The coal lies lower in the hills than farther north and west and hence has been less removed by erosion.

In the southeastern part of the township, section 13, Professor Brown found the coal as follows:

	Ft.	In.
Hard shale, unmeasured.		
Coal	2	6
Clay	1	0
Coal	1	2
Bone coal	0	4
Coal	1	1
Shale parting	0	½
Coal	1	6
Clay	2-4	0
Limestone	16	0
Shaly sandstone, unmeasured.		

In the northeastern corner of the township the coal is at its best and, for country banks, is quite extensively mined. The mines are known as the Stafford from the village across the line in Monroe county.

Coal is hauled long distances from this place. Graysville, Jackson Ridge, Rhinards Mills and other villages look to it for a supply.

The roof of the coal varies much. Numerous "rolls" or "horses" cut out the coal partly or entirely. Usually these breaks are narrow, from 10 to 12 inches, and have steep or vertical sides as if they had been deposited in narrow canyon like valleys cut in the coal. The "rolls" or "horses" are composed of soapstone with pyrite nodules.

Section 44 was measured on the G. W. Love farm on Snaler Run in the northern part of the township.

SECTION 44

	Ft.	In.
4. Coal,	1	8
3. Shaly pyrites,	0	¼
2. Coal with smut bands near top,	3	2
1. Pyrites layer,	0	¼

Directly overlying the main body of the coal is a bed of soapstone usually about 6 inches in thickness, but occasionally increasing to 2 feet. Above this is the roof coal, reported 2½ feet in thickness, the whole making a good cover.

Chemical analysis and calorific value of Section 44:

Ultimate.		*Proximate.*	
Carbon	66.18	Moisture	3.06(a)
Hydrogen	5.11	Volatile Matter	38.43
Oxygen	9.52	Fixed carbon	46.18
Nitrogen	0.86	Ash	12.33
Sulphur	6.00		
Ash	12.33		
	100.00		100.00

Calorific value ....6,865 calories.

(a) Moisture in the air-dried sample about 2%.

The sample was cut from the whole section, except part 1 which was rejected. The sample measured 3 by 2 inches, and was cut from a face that had been exposed about two weeks, but which appeared thoroughly fresh.

Jefferson Township. This township lies west of Elk which it resembles in geological conditions. The Middle Fork of Duck Creek crosses the eastern side of the township in a deep valley and its numerous tributaries also have cut through the coal. On the western side of the

township the streams after a short journey drain into Duck Creek. All in all, the township must be rated with the roughest in the state.

While the township contains a large acreage of the Meigs Creek coal, it lies well up in the ridges and hence has been extensively eroded. The supply, however, is adequate for local demands.

Enoch Township. The coal in this township lies higher in the hills than in Jefferson since the township in question is farther west. The coal has been largely removed by erosion.

Section 45 was secured on land of Mrs. Catherine A. Dillehay, one mile north of Dexter City.

SECTION 45

	Ft.	In.
6. Coal	0	3½
5. Shale	0	¼
4. Coal with 2 pyrites lamella	1	6
3. Tough streak consisting of coal, pyrites, shale and smut rock	0	9½
2. Coal with 2 thin pyrites bands	1	4¾
1. Coal in floor	0	2½

The section represents the Lower bench of the seam only. The Upper bench is not mined. It is reported about as thick as the Lower bench, but of poor quality. The mine supplies neighboring farmers, oil men and in part Dexter City.

Chemical analysis and calorific value of Section 45:

Ultimate.		*Proximate.*	
Carbon	68.53	Moisture	2.90(a)(b)
Hydrogen	5.22	Volatile Matter	37.24
Oxygen	10.78	Fixed carbon	49.70
Nitrogen	1.04	Ash	10.16
Sulphur	4.27		
Ash	10.16		
	100.00		100.00

Calorific value ....7,051 calories.

(a) Sample was very wet when cut and was dried in the sun for half an hour before putting into the can for shipment. Moisture probably in the neighborhood of 1% lower than as mined on this account.

(b) Moisture in the air-dried sample about 2%.

The sample was cut from the whole section, except parts 1 and 3 which were rejected. The lower part of the section was wet, and the sample was dried in the sun a half hour before sealing.

Part 3 of the section was sampled separately and gave the following results:

Ash	18.63
Sulphur	3.89

Country mines are found at many places, especially along Buffalo Run in the extreme southern part of the township and near the village Fuldah in the northeastern part. Formerly the coal was mined for railroad shipment in section 31 in the southwestern corner, but this work has long been abandoned. In thickness the coal is at its best in the southern part; farther north it thins and grows of less value.

Center Township. Here the coal is restricted to high narrow ridges and isolated hills. In the northwestern corner even these are too low for the coal. Many country mines are found in the township, particularly the southeastern part. The coal is fairly steady in thickness and averages about 4 feet. The supply is adequate for local use but not for railroad shipment.

Seneca Township. The area of the Meigs Creek coal in this township is small, being restricted to a few high hills or ridges. Near the hamlet of Mt. Ephraim, Professor Brown found the coal as follows:

Hard shale, unmeasured.	Ft.	In.
Bone coal	1	4
Coal	0	8
Clay shale	1	0
Coal	0	10
Parting	0	1
Coal	1	3
Parting	0	1½
Coal	1	8
Clay, unmeasured.		

The several members of this section, especially the shales and partings vary in thickness from place to place. The coals are more steady.

Noble Township. The area of the Meigs Creek coal here is small and restricted to the hill tops of the eastern and southwestern parts of the township. The coal is usually from 4 to 4½ feet in thickness and in the southwestern part supplies a small number of farmers with fuel.

In section 13 Professor Brown found the coal 258 feet above the Ames limestone.

Olive Township. This township is crossed from north to south by Duck Creek which flows through a prominent valley. East of the valley the Meigs Creek coal is wanting except in three or four sections near

the Enoch township line. The area of coal here is of course very small. In section 13 Professor Brown found the coal 4 feet 9 inches thick, but divided into three parts by two impure layers.

West of Duck Creek the area of coal is much larger and more important as a local source of fuel. However it lies well up in the hills and has been extensively eroded. The coal is thickest to the south where it sometimes reaches 4 feet. In the northern part of the township the seam ranges from 2½ to 3½ feet, but the latter thickness is uncommon.

Brookfield Township. This township lies in the northwestern corner of the county. About one-half of it is underlain with the Meigs Creek coal. Exposures of the seam are numerous, especially in the northern part.

Section 46 was taken in a bank on the H. C. Hunter farm in the northwest quarter of section 4.

SECTION 46

		Ft.	In.
10.	Bone coal,	0	5½
9.	Shale,	0	¼
8.	Coal.	0	8½
7.	Shale parting with pyrites,	0	¾
6.	Coal,	1	3½
5.	Tough streak, shale, coal, shale,	0	1½
4.	Coal, with 2 thin smut bands,	0	10½
3.	Pyrites, quite persistent, ⅛		
2.	Coal, hard,	0	4½
1.	Coal in floor, not mined,	0	9½

This mine was opened about 30 years ago and has been worked almost continuously since that time. The number of miners employed has ranged from one to ten. The coal is marketed to surrounding farmers and to the village Cumberland in Guernsey county.

While the coal has several partings, these are small and the seam may be regarded as forming a single bench which ranges ordinarily from 4 feet 4 inches in thickness to 5 feet. Of this the uppermost 5½ inches consist of bone coal and is rejected; and the lower part of the seam, varying from 4 to 8 inches in thickness and of good quality, is left in the mine owing to the large quantity of water that exists in the bottom of the coal. Hence the coal as mined ranges from 3½ to 4 feet in thickness. Occasionally the bone coal at the top of the seam is of good quality, thus increasing the thickness of workable fuel by that amount.

The nature of the roof in this part of the township is shown by the following section measured in an entry:

	Ft.	In.
Sandstone, not measured.		
Block coal, very impure	0	5½
Bone coal	0	5½
Main body of seam.		

Usually the bone coal forms the roof but in the entries this coal and the overlying shales must be removed in order that the fuel may be hauled from the mine.

Chemical analysis and calorific value of Section 46:

Ultimate.		*Proximate.*	
Carbon	66.01	Moisture	4.85(a)(b)
Hydrogen	5.26	Volatile Matter	37.28
Oxygen	12.35	Fixed carbon	48.05
Nitrogen	0.97	Ash	9.82
Sulphur	5.59		
Ash	9.82		
	100.00		100.00

Calorific value ....6,834 calories.

(a) Sample slightly wet. Moisture possibly 1% high on this acount.

(b) Moisture in the air-dried sample about 2%.

Parts 1, 5, 9 and 10 of the above section were rejected in sampling.

In the northwestern quarter of section 31 in the southwestern corner of the township, Professor Brown reports the coal as follows:

	Ft.	In.
Clay shale, roof poor.		
Coal	0	6
Clay parting with ferriferous sandstone	0	½
Coal	1	1
Hard shale with ferriferous sandstone	0	½
Coal	2	4
Clay, unmeasured.		

This section shows less than the maximum of coal which is sometimes reported to reach 5 feet.

On the farm of J. M. Pickenpaugh, northeast quarter of section 35, the coal was found as shown in Section 47.

The coal is quite hard and contains frequent layers of shale of paper thickness. At one point in the entry the soapstone and sandy shale above the coal is one foot 8 inches in thickness. Above this bed is about 3 inches of dark shale with considerable pyrites, and an inch of coal. The latter appears to be the remnant of the upper member of the seam as found in the southern and eastern parts of Noble county and along Duck Creek in Washington county.

SECTION 47

	Ft.	In.
4. Coal, with 2 shale partings	0	10
3. Coal	1	5
2. Tough streak, coal with numerous pyrites and shale partings	0	3
1. Coal, with 3 shale, and 3 pyrites partings	2	3

Chemical analysis and calorific value of Section 47:

Ultimate.		*Proximate.*	
Carbon	64.44	Moisture	3.54(a)
Hydrogen	5.12	Volatile Matter	37.41
Oxygen	10.12	Fixed carbon	45.82
Nitrogen	0.88	Ash	13.23
Sulphur	6.21		
Ash	13.23		
	100.00		100.00

Calorific value ....6,642 calories.

(a) Moisture in the air-dried sample about 2%.

The whole section except part 2 was included in the sample, and measured 3 by 2 inches. It was cut from a face that had been worked the preceding day and so was fresh.

Part 2 of the section was sampled separately and gave results as follows:

Ash	23.53
Sulphur	6.69

From 30 to 40 feet below the coal in the northern part of the township there lies a bed of sandstone that makes a good building stone. It is best seen in the court house at Cambridge.

Sharon Township. This township lies southeast of Brookfield and contains a large area of the Meigs Creek coal. The seam has been cut through by the principal streams, but probably one-half of the coal remains.

Professor Brown found the coal from 3 to 3½ feet thick in the

northern part of the township and from 4 to 4½ feet in the southern part. The roof is bad and hence requires careful timbering.

The following section of the coal was made in a bank on the L. C. Harper farm at the village Olive Green:

		Ft.	In.
Coal		1	7½
"Tough streak"	Shale	0	¼
	Coal	0	½
	Shale	0	½
Coal		1	10

The coal is very hard and impure. Clay veins are occasionally found, and balls and lenses of pyrites are common. Many lamellae of shale of paper thickness run through the seam.

At one place the coal measured 4 feet 4 inches in thickness, but on the opposite side of the entry it was reduced to 18 inches. In an old bank nearby, the coal was reported to average only 28 inches, the maximum being 36.

Jackson Township. This township which forms the southwestern corner of the county contains perhaps as much of the Meigs Creek coal as any other two townships in the county. In the northeastern corner the coal lies high in the hills and hence has been extensively eroded, but the seam dips to the southwest and in the opposite corner of the township is below drainage.

The coal is mined for the farmers' use at many places, and especially in the northwestern part of the township. From that locality the coal is hauled miles in all directions.

Professor Brown found the coal as follows in the section 12 in the northeastern corner of the township:[1]

	In.
Shale, unmeasured.	
Coal, poor	18-24
Clay	14-18
Coal	52½
Clay, unmeasured.	

The coal thickens to the west and in section 10 occasionally measures 6 feet. In section 8 in the northwestern corner of the township Professor Brown found the coal as follows:

	In.
Clay shale, poor roof.	
Coal	42-48
Clay	1- 3
Coal	4- 6
Clay, unmeasured.	

Southwest from this mine in section 19 the coal is thinner owing to a sandstone dipping down and apparently cutting out part of the coal. The seam here is usually less than 4 feet thick.

[1] Vol. V, p. 1077.

THE MEIGS CREEK COAL IN MORGAN COUNTY.

This county which is divided into two parts by the Muskingum River contains a large quantity of the Meigs Creek coal. The seam is found wherever due east of the river, and is nearly always of workable thickness. West of the river, however, the seam is thin and commonly entirely wanting. No mines exist in this part of the county but east of the river many are found.

Bloom Township. This is the northwesternmost township east of the river. The coal is small in area and is restricted to the highest ridges. Its thickness ranges from 3½ to 4½ feet with one well marked parting near the middle. Commonly the coal is underlain with nonfossiliferous limestone.

Morgan Township. This lies south of Bloom and like that township has the Meigs Creek coal in the highest ridges only. In the hills fronting on the river the coal is thin and of little value, but farther east it measures from 3 to 3½ feet with a parting of from 3 to 4 inches near the middle.

Along the river hills Professor Brown found the coal 250 feet above the Ames limestone. In the same place the Pittsburg coal is 168 feet above the limestone, making the interval between the two coal seams 82 feet.

Windsor Township. The coal in this township lies low in the hills and hence has been little removed by erosion. It follows from this that exposures of the seam are not common and hence our information concerning it is relatively meager.

In lot 75 in the northwestern corner of the township Professor Brown found the coal 3 feet thick with an irregular band of shale near the middle. The coal thickens slightly eastward and near the mouth of Meigs Creek measures from 3 to 3½ feet.

Bristol Township. This township lies east of Bloom and like that township, is bounded on the north by Muskingum county. The township has been extensively eroded by Meigs Creek and tributaries and exposures of the seam are numerous. The area of the coal is not large and is restricted to the higher ridges.

In a bank on the D. C. Lawrence farm, northeast quarter of section 21, the coal was found as shown in Section 48.

The roof in this bank is too weak to stand shooting. The coal is quite hard and contains many shale laminae of paper thickness.

SECTION 48

	Ft.	In.
8. Roof shale,		
7. Thin parting of coal,		
6. Shale, 1 to 2 inches,		
5. Coal,	1	7¼
4. Shale,	0	¼
3. Coal,	0	2¼
2. Shale,	0	1
1. Coal,	2	0

Chemical analysis and calorific value of Section 48:

Ultimate.		*Proximate.*	
Carbon	67.04	Moisture	5.05(a)(b)
Hydrogen	5.14	Volatile Mattter	37.83
Oxygen	12.26	Fixed carbon	46.75
Nitrogen	0.89	Ash	10.37
Sulphur	4.30		
Ash	10.37		
	100.00		100.00

Calorific value ....6,730 calories.

(a) Sample slightly wet. Moisture possibly a per cent. high on this account.

(b) Moisture in the air-dried sample about 2%.

The sample included parts 1, 3, 4 and 5 of the section and measured 3 by 1½ inches. The coal was badly stained owing to the light covering.

On the land of A. E. Smith in section 25 the coal was found as follows:

	Ft.	In.
Shale, unmeasured.		
Coal	0	10
Shale	1	3
Coal	2	3
Shale	0	1
Coal	2	3
Fire clay, unmeasured.		

This section shows the two benches and also a still higher layer of coal. The latter is not mined.

Sections taken in other parts of the township show similar thickness and structure, and so no further measurements will be given.

Manchester Township. The area of this township is small but the

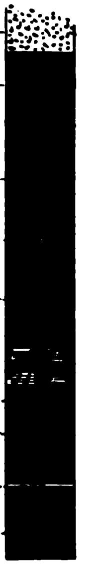
quantity of coal is relatively large for the seam is low in the hills and hence has not been extensively eroded.

Several banks are found in the vicinity of Reinersville which furnish that village with fuel and also a large area of the surrounding country.

In the mine of Louis H. Grandstaff, southwest quarter of section 29, the coal was found as represented in Section 49.

SECTION 49

	Ft.	In.
9. Soapstone, reported thickness,	15	0
8. Coal, not mined,	0	8
7. Coal,	1	2
6. Pyrites parting,	0	1/8
5. Coal,	1	1/4
4. Hard streak. coal with shale and pyrites,	0	4 1/2
3. Coal,	1	0
2. Pyrites,	0	1/4
1. Coal,	0	8 1/2



Here as elsewhere the coal contains numerous paper like layers of shale. In places the coal is bright and sometimes iridescent and then is called peacock coal. Pyrites partings are numerous, varying from one-eighth of an inch or less to half an inch or more in thickness, and often of considerable horizontal extent. Sometimes a half-dozen or more of these partings may be found in a single section.

Chemical analysis and calorific value of Section 49:

Ultimate.		*Proximate.*	
Carbon	66.19	Moisture	4.07(a)
Hydrogen	5.10	Volatile Matter	37.61
Oxygen	12.11	Fixed carbon	47.66
Nitrogen	0.87	Ash	10.66
Sulphur	5.07		
Ash	10.66		
	100.00		100.00

Calorific value .... 6,779 calories.

(a) Moisture in the air-dried sample about 2%.

The sample included the whole of the section except parts 8 and 9. It was a little wet, but nevertheless is believed to be a very fair sample.

Meigsville Township. The Meigs Creek coal is found everywhere in this township except where cut out by the larger and deeper streams. In the southern part of the township the coal varies usually from 3 to 3½ feet in thickness, and according to Professor Brown is a little irregular. Farther north the seam thickens and in the northeastern corner of the township is quite largely worked.

On the Walker farm in section 1 the coal is reported to have been mined during the past 40 years. This mine supplies quite a number of surrounding farmers and in part the village Unionville about two miles to the south. In the entry to this mine the coal was measured as follows:

	Ft.	In.
Shales, unmeasured.		
Roof coal	0	7
Shales	0	5
Coal	2	0
Shales	0	5
Coal	1	10
Fire clay, unmeasured.		

About 80 feet below this seam the Pittsburg or No. 8 coal is found. Its thickness usually varies from 18 to 24 inches. Approximately 25 feet above the Pittsburg coal is another small seam, usually from 12 to 20 inches thick. This is the Pomeroy or 8a coal.

About one-fourth of a mile up stream from the Walker mine the No. 8 coal and associated strata are seen in the bank of the creek with the following succession and approximate thicknesses:

	Ft.
Sandstone	10
Dark shales changing to light gray near the top	25
Pittsburg or No. 8 coal	1½
Brown shales	1½
Limestone	3
Sandstone	2
Bed of Dye's Fork.	

On the land of F. S. Murray, northeast quarter of section 1, the coal was found as shown in Section 50.

Chemical analysis and calorific value of Section 50:

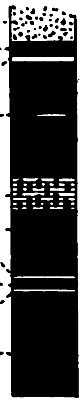
Ultimate.		*Proximate.*	
Carbon	64.77	Moisture	5.13(a)
Hydrogen	5.06	Volatile Matter	36.07
Oxygen	12.67	Fixed carbon	47.06
Nitrogen	0.87	Ash	11.74
Sulphur	4.89		
Ash	11.74		
	100.00		100.00

Calorific value .... 6,625 calories.

(a) Moisture in the air-dried sample about 2%.

SECTION 50

	Ft.	In.
10. Soapstone, unmeasured		
9. Coal, usually about 5 inches	0	1¾
8. Shale	0	¾
7. Coal, smut streak near middle	1	2
6. Bone coal	0	4
5. Coal	0	8
4. Pyrites layer	0	⅛
3. Coal	0	1
2. Pyrites	0	¼
1. Coal	1	1



Parts 6, 8 and 10 of the above section were rejected in sampling. The sample measured 3 by 1½ inches, and was cut from a face that had been exposed less than a week.

Center Township. This forms the southeastern corner of the county and contains a much larger area of the Meigs Creek coal than any other township in the county. The coal is everywhere exposed along the principal streams, Big and Little Olive Green Creeks and two or three smaller streams as well as the Muskingum River where it forms the southern boundary of the township.

In the southeast quarter of section 28 Professor Brown found the coal as follows:[1]

	Ft.	In.
Coal	0	6
Bone coal	0	3
Coal	2	0

The following measurement was made in a bank on land of J. F. Rodgers, southwest quarter of section 27, on Olive Green Creek about one and one-half miles above its mouth:

	Ft.	In.
Coal	1	6
Shales and pyrites	0	1
Coal	1	11

The coal is hard and bright and does not contain so many streaks of shale as are usually found in this seam. Likewise pyrites is less common.

According to Mr. J. O. Roberts, who has worked in several mines in this general locality, the coal is usually 3 feet 8 inches in thickness and sometimes reaches 4 feet 4 inches. Both floor and roof "roll" making variations in the thickness of the seam.

[1] Vol. V, p. 1068.

Throughout the township the coal has a similar structure, that is consists of two benches separated by a few inches of shales or an impure coal. Rarely does this parting attain a thickness of 6 inches.

In the southwest quarter of section 23 the two benches aggregate 40 inches with a 3 inch parting between. In the northern part of the township, southwest quarter of section 9, Professor Brown found the upper bench 13 inches and the lower one 30 inches in thickness, with a 4 inch parting of black shale between the two.[1]

From what has been said it is apparent that this township and others farther north contain a large quantity of the Meigs Creek coal. Thus far this has supplied a local market only and such will probably be true for many years. The time will come, however, when this coal will be sought for larger markets and then the valleys will be dotted with mining camps such as may be seen at the present time in other parts of the state.

THE MEIGS CREEK COAL IN MUSKINGUM COUNTY.

A considerable area of this coal is found in the highland in the southeastern corner of the county.

Meigs Township. This contains by far a larger quantity of this coal than any other township in the county. The township joins Brookfield of Noble on the east and Bristol of Morgan on the south, and the coal is similar to the same seam in those townships.

In the southeast quarter of section 8, Professor Brown found the coal 39 inches thick and divided into 3 nearly equal benches by shale partings.[2] In section 9 the coal is thicker and the same is true in section 26.

While the township cannot be a large producer of coal it does contain a supply adequate to the needs of its citizens for an indefinite period.

Rich Hill Township. This township lies north of Meigs and west of Spencer, the latter in Guernsey county. A high ridge crosses this township from north to south with a uniting ridge from the east. These ridges contain about all of the seam that is found in this township. The coal is about 50 inches thick but often contains considerable impurities.

Besides the areas named a little coal is found in Blue Rock and Union townships. In Blue Rock the coal is restricted to the highest ridges and the quantity small, while in Union about all that can be said is that the coal is present at two or three points.

[1] Vol. V, p. 1068.

[2] Vol. V, p. 1070.

THE MEIGS CREEK COAL IN GUERNSEY COUNTY.

The area of this coal in Guernsey county is very small, being practically restricted to a part of Spencer township in the southwestern corner of the county. Just north of the village Cumberland is a high ridge which extends west into Muskingum county. In this the coal is found near the top of the ridge. The coal is mined in a small way, the structure and thickness being similar to that in Noble county.

THE MEIGS CREEK COAL IN MONROE COUNTY.

Monroe county contains less coal above drainage than any other county in southeastern Ohio. While two seams—the Pittsburg and Meigs Creek—are mined, the production of the two combined is so small as to be insignificant.

The Meigs Creek seam is or has been mined in Seneca, Franklin and Bethel townships on the west side of the county. This territory may be regarded as an extension of the Noble county field. Another locality is near the village Mechanicsburg (Aitch P. O.) in Perry township.

As Andrews has stated the coals of this county are difficult to identify. This results from the absence of well marked horizons such as beds of fossiliferous limestone, from the thinness of the seams themselves, from the roughness of the topography and from the variations in the dip of the strata.

Seneca Township. In the northern part of this township the Meigs Creek coal is very thin or wholly wanting. On the farm of J. B. Williams in the southeast quarter of section 19, the coal has been stripped in the bed of a ravine. The following section was measured at that place:

	Ft.	In.
Limestone	1	6
Shales	2	3
Coal, poor quality	0	5
Coal	0	10
Coal, solid	0	8
Shales, unmeasured.		
Limestone, unmeasured.		

Usually the seam is about 2 feet thick but it is sometimes reported to measure 4 feet. Probably the coal is not of workable thickness in this township except in the two extreme southern sections.

Franklin Township. Along the west line of this township the Meigs Creek coal measures nearly 4 feet, sometimes more. For country banks, it is mined quite extensively, and is known as the Stafford coal. The mines, however, are across the line in Noble county.

The coal thins rapidly to the east, measuring only 18 inches on the

Hogue farm in section 9 where it has been mined by stripping. On the Baker farm in section 11, the following section of the coal was reported by the proprietor:

	Ft.	In.
Coal	0	6
Shales	0	6
Coal	1	6

The coal has been stripped on the Gibson farm in the northeast part of section 17, and is reported to be two feet thick.

The coal along the western border of this township appears to be valuable as a local fuel supply. Farther east it is much thinner, and is probably nowhere of workable thickness in the eastern part of the township.

Bethel Township. The Meigs Creek coal in this township is similar to that in Franklin. It is a well marked seam, and is mined in a small way on several farms.

On the Martin farm in section 3, the following measurement of the coal was furnished by the proprietor:

	Ft.	In.
Coal	2	6
Clay or shales	1	8
Coal	2	6

The soapstone varies from 15 to 24 inches in thickness. The bottom layer of coal is regarded the better, being harder and burning more freely.

At the Stoffel bank in section 11, the following measurement of the coal was made:

Shales and sandstone, unmeasured.	Ft.	In.
Coal	1	1
Clay or shales	1	8
Coal	3	0

As is usually the case the parting varies rapidly in thickness.

The coal is mined also on the neighboring farm of M. W. Dennis. These two banks supply the surrounding farmers with fuel, and also the oil fields in Sycamore valley and farther east in the county.

As in Franklin township the seam thins rapidly to the east and beyond the middle line of the township is rarely if ever of workable thickness.

The Mechanicsburg or Antioch Coal Field. This lies in the southeastern part of the county, and largely in Perry township.

The coal has long been mined in a small way for local use. A few years ago, the drilling for oil largely increased the demand, one mine employing 18 men. More recently the call has become much smaller and the present condition will probably be long maintained.

The following section was furnished as an average for the Bruce mine at Mechanicsburg:

	Ft.	In.
Shales, unmeasured.		
Coal	0	6
Shales	1	0
Coal	2	8
Hard soapstone, unmeasured.		

The top coal or Upper bench is reported to disappear entirely in places, and elsewhere to increase in thickness. Likewise the layer of shales varies, but rarely disappears. The lower coal is regarded superior in quality to the upper.

This coal is about 1170 feet above the Big Lime and about 1700 feet above the Berea grit. The character of the coal and its position with reference to the deeper formations just referred to proves it to be the Meigs Creek seam.

Just west of Mechanicsburg the coal disappears or is represented by a streak only, thus showing the unsteady nature of the seam. Northeast from this village the coal appears in the valley of the Little Muskingum River. The following is an average section of the seam in the Dryer bank in section 3 of Perry township, as furnished by the proprietor.

	Ft.	In.
Shales	10	0
Coal	0	10
Shales	0	1
Coal	0	5
Shales	0	½
Coal	0	4
Shales	1	0
Coal	0	5
Shales	0	2
Coal	0	8

Elsewhere along this valley the coal has occasionally been mined in a very small way. Rarely is the seam reported more than two feet in thickness, and sometimes less.

From what has been said it is plain that the Meigs Creek coal in this part of Monroe county is of little importance. At the best it cannot do more than meet a local demand from a small territory.

Switzerland and Salem Townships. These lie in the northeast corner of the county and the coal in question is everywhere due. From present data it cannot be asserted, however, that the coal is present in workable quantities.

Along the Ohio River in West Virginia, and opposite the territory in question, a number of tests have been made. Near Proctor the coal measured 2 feet 4 inches, and near Franklin Station, a few miles north, 3 feet 6 inches. These figures indicate an unsteady thickness of the seam

like that found in Ohio. They suggest also that the coal may be of value on the opposite side of the Ohio River, that is in Switzerland and Salem townships of Monroe county.

THE MEIGS CREEK COAL IN WASHINGTON COUNTY.

Aurelius Township. Nowhere in the county is the Meigs Creek coal better shown than in this township. Here as elsewhere in the county the seam is known as the Macksburg. This is a local name that has been applied to the seam by Minshall.[1] Andrews called it the Salem or Sandstone coal, because of its development near the village Salem, and because of its being often covered by a heavy bed of sandstone. He refers to it also as the Bear Creek, Coal Run or Cumberland seam.[2] Brown gave the seam in question the name Meigs Creek from its development along the stream of that name in Morgan county.[3]

Minshall has used the name Meigs Creek for a still higher seam. His succession being the Pittsburg coal, followed by the Macksburg and this by the Meigs Creek. The latter seam he places about 100 feet above the Macksburg. In other words he uses the name Macksburg for the same coal that Brown has named Meigs Creek.

The Meigs Creek coal of Brown is well shown along the valley of Duck Creek in the southern part of Noble county. Its position with reference to the Ames or Crinoidal limestone can be easily measured and thus the position of the coal determined. From the exposures of the seam along this valley, the coal can be followed to Macksburg, Washington county where it is about 290 feet above the Ames limestone and about 390 feet above the First Cow Run sand. There can be no doubt as to the Macksburg coal of Minshall being the Meigs Creek of Brown, and since the latter name has the claim of priority, it is used in this report.

The coal is exposed at many places in the township especially along the deep valley of Duck Creek and its tributaries.

Formerly the seam was mined for railroad shipment at Macksburg, but this has been discontinued many years. At present the fuel is mined on several farms for local use, among them the Dutton, Smithson, Wicksena, McManus, and Atkinson.

On the land of Charles Schimmel, section 28, one and one-half miles west of Elba, the coal was found as shown in section 52.

Pyrite lenses of considerable size are found in the coal but are not common. The coal is well spoken of by oil men who use it in boilers. No section showing the entire seam was found.

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[1] Geol. Sur. of Ohio, Vol. VI, Chap. VI.

[2] Geol. Sur. of Ohio, Vol. II, Chap. LI.

[3] Geol. Sur. of Ohio, Vol. V, Chap. XIX.

SECTION 52

	Ft.	In.
5. Coal, lower part of upper bench,	0	9½
4. Shale, and soapstone,	1	3
3. Coal,	0	8
2. Shale,	0	⅜
1. Coal,	2	3½

Chemical analysis and calorific value of Section 52:

Ultimate.		*Proximate.*	
Carbon	68.33	Moisture	3.40(a)
Hydrogen	5.31	Volatile Matter	37.95
Oxygen	10.85	Fixed carbon	49.07
Nitrogen	0.90	Ash	9.58
Sulphur	5.03		
Ash	9.58		
	100.00		100.00

Calorific value ....7,083 calories.

(a) Moisture in the air-dried sample about 2%.

Parts 1 and 3 only of the section were included in the sample which measured 4 by 2 inches. The face from which the sample was taken had been exposed for some weeks, and before sampling from 2 to 4 inches of the surface of the coal was removed.

The following is a section of the seam on the Dutton farm, near Elba:

	Ft.	In.
Shales, sandy, unmeasured.		
Coal, shaly, not mined	2	4
Shales and clay	2	6
Coal	4	6

On the land of A. F. Wooster along the valley of Duck Creek in the southern part of the township the following measurement of the coal was made:

	Ft.	In.
Coal	2	6
Shales	1	3
Coal	2	10

The quantity of this coal in Aurelius township is large and the quality fair. Probably it will not be mined on a large scale until the better coals of the state approach exhaustion. Then it will be of great value.

Salem Township. The Meigs Creek coal is shown almost everywhere in this township, along the valley of Duck Creek and its principal tributaries. In general the dip is to the southwest, but low undulations may vary it.

The seam has long been worked by farmers, and for an indefinite period will be their main reliance for fuel.

Along Bear Creek in the southwestern part of the township the seam is mined at two or three points for domestic purposes and also for work in the oil fields. On the land of George Bowen, one and one-half miles north of the township line, the coal is mined (1904) by Wagner Brothers. The seam here ranges in thickness from 4 feet to 4 feet 2 inches, is quite free from shale partings and is reported of good quality. Farther north along Bear Creek the coal thickens, measuring 5 feet. Southward the seam thins and near the mouth of this stream in Muskingum township the coal cannot be mined, or in fact be readily traced.

The thickness of this seam has been given in southern Aurelius township on Duck Creek just north of the township line. To the east and southeast from this place the coal thickens, becoming of importance along Duck Creek and the East Fork of this stream. A shale parting about one foot in thickness, near the middle of the seam, is a constant feature. The coal is fairly uniform in thickness and quality.

More than a mile northeast of Salem on the farm of Vincent Payne, the following measurement of the seam was made by Andrews:

	Ft.	In.
Coal, Upper bench	2	6
Clay parting	0	11
Coal, Lower bench	3	7

One mile southeast of Salem the following section was measured on the Twiggs farm on Paw-paw Creek:

	Ft.	In.
Coal	2	6
Shales	1	0
Coal	3	0

In the southern part of the township the seam thins, being about 4 feet on Pigeon Branch of Whipple Run, while farther south in Fearing township it becomes too thin to have any value except in the northeast corner, and is in fact difficult to trace.

Adams Township. The Meigs Creek coal is the only seam of importance in this township, and even this is of no value west of the Muskingum River. The coal usually lies a short distance only above drainage. It dips to the southwest.

Although the coal is found in the hills east of Lowell, it is not worked at present. Probably it is thinner there than farther northeast.

On the West Fork of Cats Creek the coal is mined in a small way at several places.

On the farm of William Henaker, two and one-half miles north of Lowell, two small mines are worked furnishing coal for the surrounding farmers and also for the oil fields. In one of these banks the coal varies in a short distance from 2 feet 3 inches to 3 feet in thickness. In the other bank the coal measures about 2 feet 6 inches. The operators claim that the seam here consists of only one of the benches which usually compose the Meigs Creek coal. The coal is hard and "rolly", and the roof of soft shale, preventing shooting and thus making the seam difficult to mine.

The seam is reported 3½ feet thick on the F. J. Bazil farm, one mile northwest of the Henaker farm. Andrews found the seam 4 feet 3 inches thick, slaty at the top, on the land of Nicholas Basil about three miles above the mouth of Cats Creek, while a mile farther south he found the following section on land of G. Brown:[1]

	Ft.	In.
Coal	1	6
Clay and shales	1	0
Coal	2	5

On Big Run in the western part of the township, the coal lies a few feet only above the stream bed. A number of banks have been opened along this stream but nearly all of these have been abandoned. On land of Henry Ross, a mile and one-half above the mouth of this creek, Andrews obtained the following section:[2]

	Ft.	In.
Coal	1	6
Clay	1	4
Coal	2	8

At the village Coal Run the seam dips below the level of the Muskingum River. The Felix mine, located about one-half mile below the village, is probably the second largest mine in this seam in Ohio, that at Flushing, Belmont county, ranking first. The main entry in the mine under consideration extends about half a mile into the hill, and a large quantity of coal has been removed. It has been worked at intervals since about 1890, furnishing coal to the farmers and occasionally small quantities are shipped by boat to Marietta. The maximum production was about the year 1900 when 600,000 bushels are reported to have been mined. When the mine was visited in July, 1904, the output was about 500 bushels per day. Section 53 represents the coal as found in this mine.

[1] Geol. Sur. of Ohio, Vol. II, pp. 476-477.

[2] Ibid, p. 476.

SECTION 53

	Ft.	In.
7. Soapstone, unmeasured.		
6. Coal,	0	6.
5. Smut streak, sometimes has pyrites and shale,	0	$\frac{3}{8}$
4. Coal, including a pyrites streak and smut band,	1	4
3. Hard streak, coal with numerous pyrites and shale streaks,	0	3$\frac{3}{4}$
2. Coal with 2 pyrites streaks,	0	11$\frac{3}{4}$
1. Coal forming floor in entrys,	0	4

Chemical analysis and calorific value of Section 53:

Ultimate.		*Proximate.*	
Carbon	65.88	Moisture	2.95(a)
Hydrogen	5.05	Volatile Matter	37.47
Oxygen	9.71	Fixed carbon	46.69
Nitrogen	0.92	Ash	12.89
Sulphur	5.55		
Ash	12.89		
	100.00		100.00

Calorific value .... 6,803 calories.

(a) Moisture in the air-dried sample about 2%.

Parts 1, 3 and 7 of the section were rejected in sampling. The sample measured 3 by 1½ inches.

Part 3 of the section was sampled separately and gave results as follows:

Ash	21.92
Sulphur	3.60

In the eastern part of the township the coal is of less importance. On Schlitzer's Fork of Cats Creek the seam is reported as consisting of two benches, each about 18 inches thick, separated by one foot of shale. The coal has been mined at several places along Middle Fork of Cats Creek in past years, but the banks have all been abandoned.

From what has been said it is seen that Adams township contains a large quantity of the Meigs Creek coal.

Waterford Township. The Meigs Creek coal occurs at about the river level at the village Coal Run along the eastern border of the township. Early settlers are reported to have stripped the coal from the river bed on the Shaw farm just above the village.

One and one-half miles east of Beverly the coal was formerly reached by a shaft on the J. W. Dana estate. According to Andrews the coal on this farm is as follows:[1]

	Ft.	In.
Blue clay shales	11	0
Coal	1	0
Clay	0	10
Coal	3	8

As has already been stated the Meigs Creek coal dips below the level of the river at Coal Run. It appears again in the valley of the river at and above Beverly, but is thinner, measuring only 9 inches near the river dam. Passing up the river the coal rises and becomes thicker, measuring from 2 to 3 feet near the mouth of Olive Green Creek and the post-office, Relief. This may be regarded as the southern margin of the most valuable part of the Meigs Creek coal fields.

On the extreme western border of the township the coal is lower owing to its westerly dip. The seam is much thinner also, measuring only from 7 to 11 inches on the Fisher farm, one and one-half miles south of Becketts Station.

A thin seam of coal is said to have been found in the bed of the lock at the Lake Chute dam. This may be the Meigs Creek seam though this is not certain. However, no coal was seen at or above the dam which could be referred to this seam. It has either dipped below the river or thinned out beyond recognition.

Decatur Township. The Meigs Creek coal is exposed only along Big Run in the extreme northwestern corner of the township. On the Duffie farm in section 6 where the coal has been mined the following section was measured:

	Ft.	In.
Coal	2	4
Shale	2	0
Coal	1	0

The coal dips below drainage at Morris' Station where it was formerly mined in a small way.

Except in this one section the coal is everywhere under cover in this township. No data are at hand showing the thickness or extent of the seam in this area. In fact this can be determined only by the drill.

Wesley Township. Two and one-half miles north of Bartlett, the Meigs Creek coal is exposed along Coal Run for a distance of one and one-half miles, being nowhere more than a few feet above the stream. Many years ago it was mined on the land of Joseph Wagoner on Coal Run where Andrews made the following measurement:[2]

[1] Ibid, pp. 470-1.
[2] Ibid, p. 463.

	Ft.	In.
Coal, shaly	0	3
Shale	0	2
Coal	2	0

This coal has been stripped on the land of Benj. Zumbro one and one-half miles below the Wagoner farm, and passes under cover at that place. When this territory was visited in 1905 the seam was being mined on the farm of Thomas Emmons, a short distance below the old Wagoner bank. In places the coal is overlain by a thick sandstone, the base of which sometimes curves down cutting out the coal in whole or in part.

On Wolf Creek into which Coal Run empties the horizon of the Meigs Creek coal is probably above drainage for a short distance. At the Morgan county line there is a small oil field in which the Cambridge limestone is reported to be about 320 feet below the valley of Wolf Creek. From this data the coal in question should be just above drainage. No trace of the coal, however, was seen either here or farther up this stream in Morgan county.

Liberty Township. The Meigs Creek coal is exposed in the valley of Paw-paw Creek and tributaries on the west side of the township and along Fifteen Mile Creek and tributaries in the southeastern part.

The coal is mined at several places along Campbell's Run in sections 27 and 28. In a cut at Germantown the following section of the seam was taken:

	Ft.	In.
Coal	2	6
Soapstone	1	6
Coal	3	0

It is customary in this locality to remove both divisions of the coal in mining. The lower one alone does not make a sufficiently high opening, and besides the soapstone above does not make a safe roof.

The following section of the coal was taken in the Ray bank, near the middle of section 8 in the southeastern corner of the township:

	Ft.	In.
Shale	10	0
Top coal	2	0
Soapstone	1	0
Lower coal	1	10

The soapstone layer between the two coals varies from 8 to 18 inches in thickness. The lower coal is reputed better than the upper one, but both are mined. This bank is the principal reliance of the farmers in this part of the township.

Liberty township contains a large quantity of the Meigs Creek coal, but as yet it has scarcely been touched. No shipping facilities exist, and hence mining simply meets the local needs.

Lawrence Township. The Meigs Creek coal varies considerably in this township. In the northwestern part it is of good thickness and quality, while in the eastern part it is thinner and nowhere mined. In the southeastern portion the seam is below drainage.

The following is a section of the coal in the Hamilton mine on Smoky Fork, northwest of Moss Run P. O.:

	Ft.	In.
Soapstone, unmeasured.		
Draw slate	0	4
Bone coal	0	4
Coal	4	4
Soapstone, unmeasured.		

The seam does not consist of the two benches so often found. Irregular masses of "sulphur rock" and other impurities however are occasionally found. Along Moss Run the nature of the roof varies, changing from shale to soapstone or sandstone. Occasionally a heavy ledge of the latter rock rests directly on the coal. The seam is unsteady in thickness, varying considerably in short distances. The section given above may be taken as an average.

Southwest of Moss Run P. O. the coal is much thinner, being, according to Andrews, only one foot 5 inches thick on the Baker farm in the southeastern part of section 27. Just west of the postoffice named above, Andrews found the seam 3 feet 4 inches in thickness, but it consists of four divisions, as shown below:

	Ft.	In.
Coal	0	4
Blue clay	1	8
Coal	0	4
Blue clay	1	0
Coal	1	4
Blue clay	2	1
Coal	1	4
Clay, not measured.		

Obviously the Meigs Creek coal in this territory is of a very uncertain nature. A section of the seam may be representative for the immediate area only. According to Andrews this seam dips beneath the Little Muskingum River, just below the mouth of Cow Run.[1] The exposure of the coal to which Andrews refers, in the bed of that stream, however, is no longer visible.

The coal has been mined on Cow Run about a mile above the postoffice, and also on the hillside just above the postoffice.

Newport Township. The only place in this township where the Meigs Creek coal is above drainage is along the Newell's Run uplift (Burning Springs anticlinal), about one mile west from the village Newport. This seam is now mined on the G. W. Smith farm, the coal

[1] Ibid, p. 496.

varying from 1½ to 3½ feet in thickness. Probably not more than one-third of the territory in that locality has the maximum thickness. The thinning of the seam appears to be due to the roof curving downward and cutting out the coal. The seam does not have the clay or shale parting near the middle which is so generally present. It has been worked in a small way in this neighborhood since the close of the civil war.

In the western part of the township, and especially on Long Run a higher seam is occasionally mined. On the Rightmire farm on this stream the following section was measured:

	Ft.	In.
Heavy sandstone, unmeasured.		
Shales	2	6
Coal	0	2
Shales and soapstone	1	11
Coal	5	0

This seam was formerly stripped in the bed of Long Run on the George Noland farm in section 22, but there it is only from 8 to 20 inches thick. The seam can be traced along this stream to its mouth, the Little Muskingum River. Rarely if ever is this coal found more than 20 feet above Long Run, a westward flowing stream, indicating that the coal dips to the west. This is to be expected since the territory is on the western slope of the Newells Run uplift. At the mouth of Long Run the Berea grit is about 1850 feet below the valley.

Ludlow Township. The Meigs Creek coal is above drai[illegible]
western side of this township along the Little Musk[illegible]
principal tributaries Sacketts and Wingetts Runs. T[illegible]
mined in a small way near Wingetts Run P. O., w[illegible]
ported to consist of two benches each two feet thicl[illegible]
layer of soapstone 18 inches in thickness.

On the McCurdy farm in the northwest quar[illegible]
coal was found as follows:

Coal	[illegible]
Soapstone	[illegible]
Coal	[illegible]

The seam has been worked in an irregular wa[illegible]
25 years or more. Northeastward in this township [illegible]
being only about 8 inches in thickness on the Payn[illegible]
west quarter of section 16. It has been stripped i[illegible] a run on
the McVay farm in the northwest quarter of section 10.

Obviously the seam is as uncertain in this township as in other parts of this county.

PART II.

Chemical Analyses and Calorific Tests of the Clarion, Lower Kittanning, Middle Kittanning and Upper Freeport Coals.

CHAPTER IV.

THE CLARION OR No. 4a COAL.[1]

This seam is important in four counties and is occasionally mined to a small extent in other parts of the state. The four counties are Vinton, Jackson, Lawrence and Scioto. The position of the seam is easily located by the Ferriferous limestone, the coal lying immediately below or separated from it by a thin bed of shales. The following sections illustrate this:[2]

Section on Rush Run, Milton township, Jackson county:

		Ft.	In.
Ferriferous limestone		3	0
Hard black shales		0	4
Clarion coal	Coal	1	6
	Shales	0	6
	Coal	2	0

Section at Olive Furnace, Washington township, Gallia county:

		Ft.	In.
Ferriferous limestone		8	0
Parting		0	3
Clarion coal	Coal	1	1
	Parting	0	6
	Coal	1	6
	Parting	0	1½
	Coal	0	7½
Fire clay, unmeasured.			

These sections could be duplicated to almost any extent, and so represent very well the relation of the coal to the Ferriferous limestone.

As has already been stated the important deposit of this coal is restricted to four counties and in these its known areas form only a fractional part of the counties. In Jackson county Dr. Orton reports the seam in Lick, Franklin, Jefferson, Madison, Bloomfield and Milton townships; in Vinton county in Elk, Madison, Clinton, Vinton and Wilkesville townships; in Scioto county in Bloom and Vernon townships; in Gallia county in Greenfield township, and in Lawrence county in Washington and Decatur townships.

While the coal has long been mined for domestic purposes, it is comparatively recent that the seam has been worked in a large way. Its

[1] For method of sampling see Chapter IX.

[2] Geol. Sur. of Ohio, Vol. V, chapters XVII and XVIII.

close association geographically with the excellent Wellston coal, with which it has had to compete, has retarded its development. The coal has a good future. Its quality is shown by the following analyses.

CLARION COAL.

SAMPLE 54.

Hanging Rock Mine, section 34, Vinton township, Vinton county. Sample cut from two rooms, the face of the coal being fresh in each. Sampled by Professor Edward Orton, jr., in August, 1900.

Chemical analysis and calorific value of Sample 54:

Ultimate.		*Proximate.*	
Carbon	68.52	Moisture	5.02
Hydrogen	5.49	Volatile Comb	40.31
Oxygen	13.69	Fixed carbon	46.52
Nitrogen	1.28	Ash	8.15
Sulphur	2.87		
Ash	8.15		

Calorific value .... 6,961 calories.

CLARION COAL.

SAMPLE 55.

Iron Valley Mine, section 35, Milton township, Jackson county. Sample cut from entry about 300 feet in. Mine had been idle two years but surface of coal appeared fresh. Sampled in 1900 by Professor Edward Orton, Jr.

Chemical analysis and calorific value of Sample 55:

Ultimate.		*Proximate.*	
Carbon	67.30	Moisture	5.61
Hydrogen	5.47	Volatile Comb.	38.92
Oxygen	14.16	Fixed carbon	47.38
Nitrogen	1.28	Ash	8.09
Sulphur	3.70		
Ash	8.09		

Calorific value .... 6,863 calories.

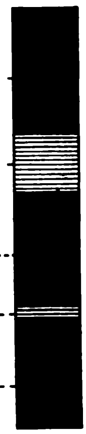
CLARION COAL.

SAMPLE AND SECTION 56.

Country Bank of Superior Coal Company, section 13, Milton township, Jackson county. Sample cut about 50 or 60 feet in the hill in comparatively new workings. Shale roof. Sampled by Professor Edward Orton, Jr., in August, 1900.

SECTION 56

	Ft.	In.
5. Coal, upper bench,	1	3
4. Shale parting,	0	7
3. Coal, middle bench,	1'-1½" to 1	2
2. Shale parting,	0	1½
1. Coal, lower bench,	1	1½



Chemical analysis and calorific value of Sample 56:

Ultimate.		*Proximate.*	
Carbon	66.14	Moisture	4.98
Hydrogen	5.39	Volatile Comb.	39.71
Oxygen	13.31	Fixed carbon	45.51
Nitrogen	1.28	Ash	9.80
Sulphur	4.08		
Ash	9.80		

Calorific value ....6,801 calories.

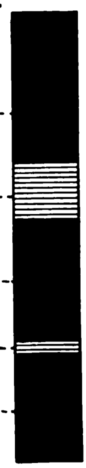
CLARION COAL.

SAMPLE AND SECTION 57.

Country Bank of Superior Coal Company, section 36 south, Milton township, Jackson county. Sample cut from 75 to 80 feet from entry. The mine had been worked recently and the surface of the coal appeared fresh. Sampled by Professor Edward Orton, Jr., in August, 1900.

SECTION 57

	Ft.	In.
5. Coal, upper bench,	1	6
4. Shale parting,	0	7
3. Coal, middle bench,	1	2½
2. Shale parting,	0	1½
1. Coal, lower bench,	1	1



Chemical analysis and calorific value of Sample 57:

Ultimate.		*Proximate.*	
Carbon	67.51	Moisture	4.71
Hydrogen	5.44	Volatile Comb.	40.51
Oxygen	13.45	Fixed carbon	46.17
Nitrogen	1.26	Ash	8.61
Sulphur	3.73		
Ash	8.61		

Calorific value ....6,911 calories.

CLARION COAL.

SAMPLE AND SECTION 58.

Mine of Vinton Coal Company, section 33, Vinton township, Vinton county. Sampled by Professor Edward Orton, Jr., in August, 1900.

SECTION 58

	Ft.	In.
7. Pyrites lenses and bone coal,	0	2
6. Coal, upper bench,	1	4
5. Shales and coal,	0	9
4. Coal, middle bench	0	11
3. Shale parting,	0	1½
2. Coal, lower bench,	0	11
1. Clay, unmeasured,		

Chemical analysis and calorific value of Sample 58:

Ultimate.		*Proximate.*	
Carbon	64.91	Moisture	4.61
Hydrogen	5.36	Volatile Comb.	41.35
Oxygen	12.05	Fixed carbon	42.94
Nitrogen	1.30	Ash	11.10
Sulphur	5.28		
Ash	11.10		

Calorific value ....6,760 calories.

CLARION COAL.

SAMPLE AND SECTION 59.

Mine of Elmer Keck & Company, section 24, Wilkesville township, Vinton county. At point of sampling the limestone roof was replaced by sandstone. Sampled by Professor Edward Orton, Jr., in August, 1900.

SECTION 59

	Ft.	In.
5. Coal, upper bench,	1	8
4. Shale parting,	0	11
3. Coal, middle bench,	1	1½
2. Pyrites,	0	1½
1. Coal, lower bench,	1	2½

Chemical and calorific value of Sample 59:

Ultimate.		*Proximate.*	
Carbon	65.04	Moisture	4.72
Hydrogen	5.36	Volatile Comb.	39.88
Oxygen	12.95	Fixed carbon	44.19
Nitrogen	1.28	Ash	11.21
Sulphur	4.16		
Ash	11.21		

Calorific value .... 6,744 calories.

CLARION COAL.

SAMPLE AND SECTION 60.

Pittinger Mine, Wellston, Jackson county. The coal has a shale roof. Sampled by Professor Edward Orton, Jr., in August, 1900.

SECTION 60

	Ft.	In.
6. Coal, upper bench,	0	11½
5. Shale parting,	0	9
4. Coal, middle bench,	1	4
3. Shale parting,	0	1½
2. Coal, lower bench,	1	2
1. Clay, unmeasured,		

Chemical analysis and calorific value of Sample 60:

Ultimate.		*Proximate.*	
Carbon	66.52	Moisture	5.33
Hydrogen	5.50	Volatile Comb.	41.01
Oxygen	14.58	Fixed carbon	45.26
Nitrogen	1.28	Ash	8.40
Sulphur	3.72		
Ash	8.40		

Calorific value .... **6,825 calories.**

CLARION COAL.

SAMPLE AND SECTION 61.

Lawler Mine, Minerton, Vinton county. Sampled by Professor Edward Orton, Jr., in August, 1900.

SECTION 61

	Ft.	In.
6. Coal, upper bench,	1	6½
5. Shale parting,	0	6½
4. Coal, middle bench,	1	2
3. Shale parting,	0	1½
2. Coal, lower bench, including a pyrites band near bottom,	1	1
1. Fire clay,		

Chemical analysis and calorific value of Sample 61:

Ultimate.		*Proximate.*	
Carbon	67.17	Moisture	4.52
Hydrogen	5.44	Volatile Comb.	40.10
Oxygen	13.03	Fixed carbon	46.53
Nitrogen	1.28	Ash	8.85
Sulphur	4.23		
Ash	8.85		

Calorific value .... **6,904 calories.**

CLARION COAL.

SAMPLE AND SECTION 62.

Old Limestone Furnace Mine, section 32, Bloomfield township, Jackson county. Sample cut about 300 feet from entry. Limestone roof. Sampled by Professor Edward Orton, Jr., in August, 1900.

SECTION 62

		Ft.	In.
8.	Limestone,	6	0
7.	Bone coal,	0	3
6.	Coal, upper bench,	7	10
5.	Shale parting,	0	6
4.	Coal, middle bench,	1	2½
3.	Shale parting,	0	1½
2.	Coal, lower bench,	0	9
1.	Clay, unmeasured,		

Chemical analysis and calorific value of Sample 62:

Ultimate.		*Proximate.*	
Carbon	62.05	Moisture	5.31
Hydrogen	4.98	Volatile Comb.	37.33
Oxygen	12.12	Fixed carbon	43.82
Nitrogen	1.23	Ash	13.54
Sulphur	6.08		
Ash	13.54		

Calorific value ....6,394 calories.

CLARION COAL.

SAMPLE AND SECTION 63.

Hall's Mine, Kitchen station, Madison township, Jackson county. Sample cut well under the hill. Limestone roof. Sampled by Professor Edward Orton, Jr., in August, 1900.

Chemical analysis and calorific value of Sample 63:

Ultimate.		*Proximate.*	
Carbon	62.57	Moisture	4.90
Hydrogen	4.89	Volatile Comb.	35.75
Oxygen	11.47	Fixed carbon	45.65
Nitrogen	1.23	Ash	13.70
Sulphur	6.14		
Ash	13.70		

Calorific value ....6,460 calories.

CLARION COAL.

SAMPLE AND SECTION 64.

Mine of Morgan & Horton, Eifort station, Bloom township, Scioto county. Coal has ample cover. Sampled in August, 1901, by Professor Edward Orton, Jr.

Chemical analysis and calorific value of Sample 64:

Ultimate.		*Proximate.*	
Carbon	65.30	Moisture	6.80
Hydrogen	5.33	Volatile Comb.	37.92
Oxygen	15.35	Fixed carbon	45.94
Nitrogen	1.23	Ash	9.34
Sulphur	3.45		
Ash	9.34		

Calorific value ....6,577 calories.

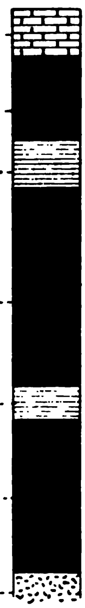
CLARION COAL.

SAMPLE AND SECTION 65.

Mine of McGugin & Company, section 7, Decatur township, Lawrence county. The sample was cut from an old entry where the coal was weathered. Sampled in August, 1901, by Professor Edward Orton, Jr.

SECTION 65

	Ft.	In.
7. Limestone	8	0
6. Coal, upper bench	0	10
5. Shale parting	0	6
4. Coal, middle bench	2	0
3. Shale parting	0	4
2. Coal, lower bench	1	6
1. Clay, unmeasured		



Chemical analysis and calorific value of Sample 65:

Ultimate.		*Proximate.*	
Carbon	57.92	Moisture	6.34
Hydrogen	4.91	Volatile Comb.	35.30
Oxygen	13.40	Fixed carbon	40.95
Nitrogen	1.07	Ash	17.41
Sulphur	5.29		
Ash	17.41		

Calorific value ....5,967 calories.

CLARION COAL.

SAMPLE AND SECTION 66.

Mine of J. R. Edwards, section 23, Washington township, Lawrence county. Sample cut 75 feet from entrance to mine where the coal was fresh. Sampled by Professor Edward Orton, Jr., in August, 1901.

SECTION 66

	Ft.	In.
7. Limestone,		
6. Coal, upper bench,	1	0
5. Shale parting,	0	5
4. Coal, middle bench,	1	6
3. Shale parting,	0	2
2. Coal, lower bench,	0	6
1. Clay, unmeasured,		

Chemical analysis and calorific value of Sample 66:

Ultimate.		*Proximate.*	
Carbon	63.32	Moisture	6.00
Hydrogen	5.26	Volatile Comb.	39.16
Oxygen	13.24	Fixed carbon	42.98
Nitrogen	1.22	Ash	11.86
Sulphur	5.10		
Ash	11.86		

Calorific value ....6,519 calories.

CLARION COAL.

SAMPLE AND SECTION 67.

Mine of McGugin & Company, Olive Station, Decatur township, Lawrence county. Sample cut well under hill where coal was clean and bright. Sampled by Professor Edward Orton, Jr., in August, 1901.

Chemical analysis and calorific value of Sample 67:

Ultimate.		*Proximate.*	
Carbon	60.22	Moisture	5.86
Hydrogen	5.06	Volatile Comb.	37.25
Oxygen	12.90	Fixed carbon	41.61
Nitrogen	1.18	Ash	15.28
Sulphur	5.36		
Ash	15.28		

Calorific value ....6,185 calories.

SECTION 67

	Ft.	In.
6. Limestone,	7 to 8	0
5. Coal, upper bench,	0	11½
4. Shale parting,	0	5½
3. Coal, middle bench with 1 thin parting,	2	2½
2. Shale parting,	0	10½
1. Coal, lower bench,	1	6

CLARION COAL.

SAMPLE AND SECTION 68.

Mine of Isaac Hall, section 15, Decatur township, Lawrence county. Sample cut a half mile from entrance. Surface of coal had been exposed two months. Sampled by Professor Edward Orton, Jr., in August, 1901.

SECTION 68

	Ft.	In.
7. Limestone,		
6. Coal, upper bench,	1	0.
5. Shale parting, 5 to 7 inches		
4. Coal, middle bench,	1	6.
3. Shale parting, 2 to 3 inches		
Coal, lower bench, 6 to 7 inches		
1. Clay, unmeasured,		

Chemical analysis and calorific value of Sample 68:

Ultimate.		*Proximate.*	
Carbon	65.53	Moisture	6.11
Hydrogen	5.42	Volatile Comb.	38.43
Oxygen	14.28	Fixed carbon	45.52
Nitrogen	1.22	Ash	9.94
Sulphur	3.61		
Ash	9.94		

Calorific value ....6,643 calories.

CLARION COAL.

SAMPLE AND SECTION 69.

Mine of J. T. Dickson, section 27, Elk township, Vinton county. Coal had 50 feet cover. Sample cut from fresh surface by E. E. Somermeier in September, 1901.

SECTION 69

	Ft.	In.
5. Shale,		
4. Coal, upper bench,	0	8
3. Bone coal,	0	5
2. Shale parting,	0	5
1. Coal, lower bench,	2	10

Chemical analysis and calorific value of Sample 69:

Ultimate.		*Proximate.*	
Carbon	67.17	Moisture	4.95
Hydrogen	5.40	Volatile Comb.	39.17
Oxygen	13.28	Fixed carbon	46.56
Nitrogen	1.30	Ash	9.32
Sulphur	3.53		
Ash	9.32		

Calorific value ....6,914 calories.

CLARION COAL.

SAMPLE AND SECTION 70.

Mine of Trace, Rider & Plummer, section 29, Madison township, Vinton county. Sample cut well under the hill. Some doubt as to its

being the Clarion coal. Sampled by E. E. Somermeier in September. 1901.

SECTION 70

	Ft.	In.
5. Shale,		
4. Coal, upper bench,	1	7
3. Shale parting,	0	1
2. Coal, lower bench,	1	0
1. Clay, unmeasured,		

Chemical analysis and calorific value of Sample 70:

Ultimate.		*Proximate.*	
Carbon	67.92	Moisture	5.02
Hydrogen	5.48	Volatile Comb.	39.90
Oxygen	12.98	Fixed carbon	46.11
Nitrogen	1.33	Ash	8.97
Sulphur	3.32		
Ash	8.97		

Calorific value .... 6,960 calories.

CHAPTER V.

THE LOWER KITTANNING OR NO. 5 COAL.[1]

This seam can be traced from Mahoning county southwest across the state to Lawrence. While it is mined in a number of places, it is of value in few.

The seam is important on the western side of Lawrence county, where it is known as the New Castle coal. The position of the seam is well shown by the following general section.[2]

Middle Kittanning or Sheridan seam, No. 6.
Interval 40 feet.
Lower Kittanning or Newcastle seam, No. 5.
Interval 20-30 feet.
Ferriferous limestone.
Interval 0-15 feet.
Clarion coal or Limestone seam, No. 4a.

The thickness and character of the coal in this field is adequately shown by the sections and analyses which follow. The coal is extensively used at Ironton, in fact is the main fuel reliance of that city.

The coal is found in fair thickness in the eastern part of Jackson county which lies north of Lawrence, but its development has been retarded by the presence of two more valuable seams, the Wellston and Clarion. It does not there promise to become more than a local source of fuel for years.

Northward from Jackson the seam thins until Perry county is reached. In the eastern part of this county especially in Clay and Pike townships it is important, and is known locally as the Lower New Lexington coal. Following is a generalized section of this part of the field.[3]

	Ft.
Lower Freeport sandstone or shale	30-40
Middle Kittanning coal, No. 6	5-13
Shales and Kidney ore	2-10
Sandy shale, mainly	10-20
Lower Kittanning coal, No. 5	1- 3
Kittanning clay and shales	10-20
Ferriferous limestone and Baird ore	1- 4

The two sections and analyses on a later page show very well the thickness, structure and composition of this coal.

[1] For method of sampling see Chapter IX.
[2] Geol. Sur. of Ohio, Vol. V, p. 1037.
[3] Vol. V, p. 919.

Continuing northeast Muskingum county is reached. There the coal is of some importance, especially in the vicinity of Zanesville and in Washington township. The area, however, is small. It is not found in workable thickness north of the Baltimore & Ohio Railroad nor is it found in the river hills south of the city. Sometimes the coal has three benches but occasionally the lower parting disappears The seam is known locally as the "Four-foot" or Lower Zanesville.

Through the northern part of Muskingum county, through Coshocton and nearly the whole of Tuscarawas, the Lower Kittanning coal is thin and of little value. In Sandy township in the northeast corner of Tuscarawas county the coal is thicker, but the clay below the coal is often more valuable than the coal itself. The coal has long been mined in the vicinity of Mineral Point. It is an important local source of fuel and has been shipped for many years.

The coal is of some value in Pike and Sandy townships in the southeastern part of Stark county where it is mined in a small way for local use. The coal attains a thickness of about four feet. Sometimes it forms three benches and sometimes only two.

The coal is at its best in the northern part of Columbiana county, especially in the vicinity of Leetonia. Orton rated the field the most important of this seam in the state.[1] The area is not large but the coal is of good quality. It has been coked for local iron works. The seam usually has two benches "the lower of which is much the purer." Sometimes the upper bench has to be rejected. The following section shows the succession in this locality:

	Ft.	In.
Sandstone, Lower Freeport	20	0
Coal, Middle Kittanning	0	8
Sandstone and shales	15	0
Coal, Lower Kittanning	1	4
Shales and ore nodules	40	0
Draw slate	1	0
Coal, Clarion	3	0

From Columbiana county the coal can be traced northward into Mahoning. Probably Green township contains the best of the deposit. The area, however, is small and does not promise to become important except for a local demand. A section and analysis of the seam in this township may be found on a later page.

The seam is found also in the northern part of Jefferson county. It is there similar to the corresponding coal in Columbiana and Mahoning counties. The quantity, however, is small.

[1] Vol. V, p. 187.

LOWER KITTANNING COAL.

SAMPLE AND SECTION 71.

Copelin's Mine, section 2, Pike township, Perry county. The sample is an excellent one, and was cut from a section 12 by 5 inches. The No. 6 coal is found about 20 feet above the No. 5. Sampled by B. A. Eisenlohr in July, 1902.

SECTION 71

	Ft.	In.
7. Shale,	0	7
6. Coal, upper bench,	0	6
5. Horn coal,	0	1
4. Coal, middle bench,	1	0
3. Parting,	0	½
2. Coal, lower bench,	1	9
1. Fire clay,		

Chemical analysis and calorific value of Sample 71:

Ultimate.		*Proximate.*	
Carbon	64.78	Moisture	6.85
Hydrogen	5.26	Volatile Comb.	35.22
Oxygen	13.86	Fixed carbon	47.77
Nitrogen	1.22	Ash	10.16
Sulphur	4.72		
Ash	10.16		

Calorific value ....6,591 calories.

LOWER KITTANNING COAL.

SAMPLE AND SECTION 72.

McMonigal's Mine, section 14, Pike township, Perry county. Coal soft and dirty. Sample representative and cut from a section 18 by 4 inches by B. A. Eisenlohr in July, 1902.

Chemical analysis and calorific value of Sample 72:

Ultimate.		*Proximate.*	
Carbon	68.34	Moisture	6.74
Hydrogen	5.47	Volatile Comb.	37.05
Oxygen	15.25	Fixed carbon	49.09
Nitrogen	1.24	Ash	7.12
Sulphur	2.58		
Ash	7.12		

Calorific value ....6,885 calories.

SECTION 77

		Ft.	In.
13.	Dark shale,		
12.	Coal,	0	8
11.	Bone coal,	0	⅜
10.	Coal,	0	1½
9.	Soot streak,	0	¼
8.	Coal,	1	1
7.	Pyrites,	0	¼
6.	Coal,	0	4¼
5.	Soot streak,	0	½
4.	Coal,	0	4½
3.	Bone coal,	0	½
2.	Coal,	0	9¼
1.	Fire clay,		

Chemical analysis and calorific value of Sample 77:

Ultimate.		*Proximate.*	
Carbon	69.75	Moisture	5.30(a)
Hydrogen	5.46	Volatile Matter	38.73
Oxygen	12.65	Fixed carbon	48.26
Nitrogen	1.18	Ash	7.71
Sulphur	3.25		
Ash	7.71		
	100.00		100.00

Calorific value ....7,168 calories.

(a) Moisture in the air-dried sample from 2½ to 3 per cent.

LOWER KITTANNING COAL.

SAMPLE AND SECTION 77a.

Mine of John D. Smith, Washingtonville, Green township, Mahoning county. Sample taken about 1,000 feet from entrance where the cover over the coal measured about 60 feet. The sample was a section 6 by 4 inches, and was cut by D. D. Condit, in December, 1907. The top 4 inches of the bone coal was rejected.

SECTION 77a

		Ft.	In.
5.	Shale with kidney ore,		
4.	Bone coal,	0	7
3.	Coal,	1	10
2.	Fire clay,		
1.	Limestone,		

Chemical analysis and calorific value of Sample 77a:

Ultimate.		*Proximate.*	
Carbon	73.84	Moisture	5.23(a)
Hydrogen	5.50	Volatile Matter	36.86
Oxygen	12.36	Fixed carbon	53.19
Nitrogen	1.41	Ash	4.72
Sulphur	2.17		
Ash	4.72		
	100.00		100.00

Calorific value .... 7,502 calories.

(a) Moisture in the air-dried sample from 2½ to 3 per cent.

LOWER KITTANNING COAL.

SAMPLE AND SECTION 77b.

Coal from mine of Great Western Sewer Pipe Works, Toronto, Jefferson county. The clay below the coal is removed and then the coal shot down. The coal is of secondary interest. The sample is fairly good and was cut by D. D. Condit, in December, 1907.

SECTION 77b

	Ft.	In.
4. Dark shale,		
3. Bone coal,	0	4
2. Coal,	3	1
1. Fire clay,		

Chemical analysis and calorific value of Sample 77b:

Ultimate.		*Proximate.*	
Carbon	74.20	Moisture	2.46(a)
Hydrogen	5.38	Volatile Matter	38.48
Oxygen	7.93	Fixed carbon	51.66
Nitrogen	1.27	Ash	7.40
Sulphur	3.82		
Ash	7.40		
	100.00		100.00

Calorific value .... 7,591 calories.

(a) Moisture in the air-dried sample about one to one and one-half per cent.

CHAPTER VI.

THE MIDDLE KITTANNING OR NO 6 COAL.[1]

This has always been considered the most valuable seam in Ohio. It extends entirely across the state from Columbiana to Lawrence counties, and is mined in a large or small way from the Pennsylvania line to the Ohio River. It is the most persistent seam in the state, though of course it varies in thickness from place to place.

It is mined in a small way at Sheridan, Lawrence county, in the extreme southern part of the state. A section of the seam at this place is given on a later page. There, however, the Lower Kittanning or New Castle coal is the more important.

Farther north in the county the coal is worked at a number of places and the quality is good, sometimes excellent.

The following section measured at Mt. Vernon Furnace shows very well the stratigraphy of the coal formations in this part of the state.[2]

	Ft.
Sandy shale with nodules of ore	12
Upper Freeport, No. 7 or Waterloo coal (Blossom)	
Sandy shales	11
Not seen	15
Shaly sandstone	12
Lower Freeport, No. 6 or Hatcher coal (Blossom)	
White clay	7
Shales	8
Sandstone	20
Slate	4
Middle Kittanning, No. 6, or Sheridan coal.	
Shales with kidneys of ore	16
Sandstone massive	29
Coal blossom.	
Shaly sandstone	7
Lower Kittanning, No. 5 or Newcastle coal.	
Not seen	8
White sandstone	6
Shales	4
Limestone ore.	
Ferriferous limestone	6
Clarion, No. 4a or Limestone coal.	
White sandstone	6
Coal blossom.	
Shales	16
Brookville, No. 4 coal.	
Sandstone	16
Not seen	6

[1] For method of sampling see Chapter IX.
[2] Vol. V, p. 1038.

From Lawrence county the seam extends across the northwest corner of Gallia where the coal is more valuable though not extensively mined. There the coal consists of three benches surmounted by a bed of clay, above which in turn is a thin layer of coal that Dr. Orton regarded as a continuation of the upper part of the great seam in the Hocking Valley.[1] The seam lies about 215 feet above the Cambridge limestone.

From Gallia the seam can be traced through the eastern part of Jackson county. There the coal is thinner and of less value. It cannot be mined for shipment as long as several thicker and more valuable seams are found in the same locality. The position of the seam is from 55 to 65 feet above the Ferriferous limestone.

The coal is found on the eastern side of Vinton county and has long been mined at Zaleski on the B. & O. S.-W. R. R. The seam consists of three benches, and the structure may be regarded normal for the state.

Continuing northeast Waterloo township, Athens county is reached and this constitutes the southwestern corner of the great Hocking Valley field. The most valuable part of this field includes the northern half of Athens, the eastern edge of Hocking and the southern third of Perry counties. Orton rated it the most important coal field in the state. Its only rival is the Pittsburg field of eastern Ohio whose output is increasing rapidly and will probably soon surpass that of the Hocking Valley field.

Concerning the structure of the seam in this field Dr. Orton has said:[2] "In structure the Hocking Valley coal always has the three benches of the normal Middle Kittanning seam, with some addition of its own. In other words the great vein consists of the normal three-bench seam of Middle Kittanning age covered and reinforced by a Hocking Valley supplementary seam, the latter consisting of one or two or more benches. The supplementary seam is separated from the original seam by a thin shale parting, which is often disregarded in mining, but which is for the most part distinctly recognizable when looked for."

"The supplementary seam of the Hocking Valley is, in the general view, counted with the upper bench of the normal seam, the whole being known as the top coal. It has a maximum thickness of 10 feet. All the thickness of the Hocking Valley seam in excess of 6 feet, and in many parts of the field all in excess of 4½ feet, is to be credited to the supplementary seam."

"There are numerous irregular partings in this top coal when it becomes thick, only one of which is widely extended and measurably regular. A four-inch black slate, known as the third slate, and charged with sigillaria impressions, is found 8 to 9 feet above the bottom of the Great Vein, everywhere throughout Monroe township, in the Sunday Creek Valley. As it now appears, it is the same horizon at which a constant layer of cannel or horn coal is found throughout the western por-

[1] Vol. V, p. 1047.
[2] Vol. V, p. 921.

tions of the Great Vein. The coal above the slate becomes a rider seam. It runs too high in ash in most of the field where it occurs to be fairly marketable. It reaches a maximum thickness of 4 feet, but most of it is left in the mines."

Concerning the character of the coal Dr. Orton said: "The character of the coal throughout the field is fairly uniform. Taken as a whole, it is an open-burning coal of pronounced character, but the lower bench, burned by itself, is somewhat cementing. It is distinctly laminated and holds a moderate proportion of mineral charcoal. It ignites easily, swells slightly in burning, and leaves a white or gray ash. It is well approved for steam generation, and also for rolling mill fuel. To household use it is admirably adapted, rivalling in this line of service the block coals of the Mahoning and Tuscarawas Valleys."

The numerous sections and analyses found on later pages amply show the thickness, structure and composition of the seam.

The following section measured in Monday Creek township on the extreme western edge of the Hocking Valley field shows the position of the Middle Kittanning with reference to the lower coals.[1]

	Ft.	In.
Middle Kittanning, No. 6, coal	3	0
Shales	24	0
Lower Kittanning, No. 5, coal	11	0
Ferriferous limestone and Baird ore	0	9
Interval	70	0
Upper Mercer limestone	1	3
Upper Mercer coal, No. 3a	3	0
Interval	45	0
Lower Mercer limestone.		

In Perry county northeast of the Hocking Valley field the seam under consideration thins but is nevertheless of value. It has long been worked and will increase in importance with the exhaustion of the richer territory already reviewed.

The seam is the main reliance of Muskingum county, both for domestic purposes and manufacturing. It extends across the county from the southwest to the northeast and is mined in the large or small way wherever present. It commonly ranges from 2½ to 3½ feet in thickness and is quite steady in thickness, structure and composition.

The seam is found in the southeastern part of Coshocton county and is the main reliance of that community for fuel. The seam commonly consists of two benches and over considerable of the territory ranges from 3 to 3½ feet in thickness. Its quality is good but in places the seam is too soft to bear transportation well.

In Tuscarawas county, lying east of Coshocton, the seam is found over a large area, existing in every township with the possible exception of Perry. It is at its best in the southeast corner where the coal occa-

[1] Vol. V, p. 907.

sionally reaches 5 feet in thickness. Usually the coal has the 3 benches which are so characteristic. In 1906 this county produced over 1,400,000 tons of coal, ranking seventh in the state. Much the larger part of this was from the seam under consideration.

Holmes county lies north of Coshocton and contains the Middle Kittanning seam over much of the southern part. The coal sometimes reaches 3½ feet in thickness and usually has two benches. Lack of transportation facilities has retarded the development of the seam but it has rendered marked service to the farmers.

The following section, taken in German township in the southeastern part of the county, shows very well the position of the seam with reference to the underlying strata:[1]

	Ft.
Gray shales	15
Black shales	6
Middle Kittanning coal (exposed)	2
Shale and clay	10
Sandstone	12
Shales with kidney ore	17
Lower Kittanning coal (exposed)	2
Clay	3
Shales with kidney ore	17
Sandstone	3
Clay blossom. Clarion?	
Shaly sandstone	22
Putnam Hill limestone	1
Brookville coal. Blossom.	
Sandstone with iron ore	15
Concealed	26
Upper Mercer coal	4

The Middle Kittanning coal is found in the western part of Carroll county, but it is there of comparatively small importance. According to Orton the Upper Freeport or No. 7 seam is the one valuable coal deposit of that county.[2]

The seam is found in the southeastern part of Stark county and has long been mined in a large or small way. The coal has a maximum thickness of nearly 4 feet and is of good quality. Sometimes only two benches are found and at other times three.

In this very rapid survey of the Middle Kittanning field Columbiana county has been reached. Dr. Orton thus speaks of the seam in this county: "The Middle Kittanning coal is less valuable, relatively and absolutely, in Columbiana county than in any other county of the state in which it occupies as wide an area. It is less than 1 foot in thickness wherever seen through the northern and central portions of the county, and is nowhere opened here. In the Ohio Valley it is known as the

[1] Vol. V, p. 840.
[2] Vol. V, p. 244.

Block Vein and as the Hammondville Strip Vein, and about East Liverpool as the Dry Run coal. Its quality here is so good that it is extensively worked in small mines, although its thickness ranges between 20 and 32 inches, rarely reaching the latter figure."[1].

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 78.

Bristol Coal Company, section 30, Pike township, Perry county. Mine was wet and muddy and some mud fell into the coal. Nevertheless the sample is believed to be fair. It was 10 inches wide and 5 inches deep, and was taken by B. A. Eisenlohr in July, 1902.

The No. 5 or Lower Kittanning seam was mined in the same locality.

SECTION 78

	Ft.	In.
6. Slate,		
5. Bone coal,		10 to 12
4. Coal, upper bench,	1	3
3. Parting,	0	1½
2. Coal, lower bench,	1	7
1. Fire clay,		

Chemical analysis and calorific value of Sample 78:

Ultimate.		*Proximate.*	
Carbon	68.29	Moisture	7.00
Hydrogen	5.58	Volatile Comb.	37.12
Oxygen	15.59	Fixed carbon	48.93
Nitrogen	1.26	Ash	6.95
Sulphur	2.33		
Ash	6.95		

Calorific value .... 6,880 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 79.

Upson Mine, section 21, Salt Lick township. Perry county. Soft coal above upper bench rejected. Sample, 6 inches wide and 4 inches deep, was taken by B. A. Eisenlohr in July, 1902.

[1] Vol. V, p. 186.

SECTION 79

	Ft.	In.
7. Soft coal,	6 to 18	
6. Coal, upper bench,	4	3
5. Parting,	0	2½
4. Coal, middle bench,	1	6
3. Parting,	0	1
2. Coal, lower bench,	1	10
1. Fire clay,		

Chemical analysis and calorific value of Sample 79:

Ultimate.		*Proximate.*	
Carbon	68.30	Moisture	7.76
Hydrogen	5.46	Volatile Comb.	33.50
Oxygen	16.14	Fixed carbon	51.27
Nitrogen	1.18	Ash	7.47
Sulphur	1.45		
Ash	7.47		

Calorific value ....6,772 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 80.

Mine of Haydenville Coal Company, section 1, Green township, Hocking county. Thickness of seam is quite irregular. In places the upper bench is entirely wanting. Its greatest thickness is about 26 inches. The mine was dry and the sample very fair. Sampled by B. A. Eisenlohr in July, 1902.

The No. 5 or Lower Kittanning seam was noted about 33 feet below and approximately 28 inches thick.

SECTION 80

	Ft.	In.
8. Sandstone,		
7. Draw slate,	0	4
6. Coal, upper bench,	1	3
5. Parting,	0	3
4. Coal, middle bench,	2	2½
3. Parting,	0	4
2. Coal, lower bench,	1	1
1. Fire clay,		

Chemical analysis and calorific value of Sample 80:

Ultimate.		*Proximate.*	
Carbon	68.40	Moisture	6.55
Hydrogen	5.45	Volatile Comb.	37.30
Oxygen	15.43	Fixed carbon	49.18
Nitrogen	1.18	Ash	6.97
Sulphur	2.57		
Ash	6.97		

Calorific value .... 6,901 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 81.

Mine of J. W. Washburn, section 22, Starr township, Hocking county. The roof is undulating and hence the thickness of the coal varies. The lower bench as well as the upper thins out in places. Sample 14 inches wide by 4½ inches in depth. A little dirt fell into the sample, which was taken by B. A. Eisenlohr in July, 1902.

SECTION 81

	Ft.	In.
6. Sandstone,		
5. Draw slate,	0	6½
4. Coal, upper bench,	2	6
3. Parting,	0	1
2. Coal, lower bench,	0	5
1. Fire clay,		

Chemical analysis and calorific value of Sample 81:

Ultimate.		*Proximate.*	
Carbon	67.33	Moisture	6.52
Hydrogen	5.49	Volatile Comb.	38.30
Oxygen	14.43	Fixed carbon	47.15
Nitrogen	1.20	Ash	8.03
Sulphur	3.52		
Ash	8.03		

Calorific value ....6,850 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 82.

Bank of George Cherry, section 3, Swan township, Vinton county. Upper bench much harder than lower one. Sample cut about 60 feet from outcrop and is very good. It was taken by B. A. Eisenlohr in July, 1902.

Chemical analysis and calorific value of Sample 82:

Ultimate.		*Proximate.*	
Carbon	66.26	Moisture	4.90
Hydrogen	5.40	Volatile Comb.	39.16
Oxygen	12.71	Fixed carbon	45.79
Nitrogen	1.23	Ash	10.15
Sulphur	4.25		
Ash	10.15		

Calorific value ....6,845 calories.

SECTION 82

	Ft.	In.
5. Shale,	2	2½
4. Coal, upper bench,	1	8
3. Parting,	0	2
2. Coal, lower bench,	0	11
1. Bone coal,	0	8

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 82a.

Mine of G. L. Chatfield, Sheridan, Lawrence county, the location being at almost the southernmost point in the state. The mine is small and probably never yields more than 200 bushels per day. The sample was taken about 300 feet from the entrance where the vertical cover was about 250 feet. The face from which the coal was cut had been exposed only three days. Sample consists of a section about 5 by 3 inches and was cut by D. D. Condit in November, 1907.

SECTION 82 a

	Ft.	In.
5. Shale, unmeasured,		
4. Coal with shale,	0	6
3. Shale persistent,	0	½
2. Coal,	2	6
1. Shale, unmeasured,		

Chemical analysis and calorific value of Sample 82a:

Ultimate.		*Proximate.*	
Carbon	64.95	Moisture	6.64(a)
Hydrogen	5.16	Volatile Matter	34.28
Oxygen	14.42	Fixed carbon	48.16
Nitrogen	1.23	Ash	10.92
Sulphur	3.32		
Ash	10.92		
	100.00		100.00

Calorific value ....6,626 calories.

(a) Moisture in the air-dried sample from 2½ to 3 per cent.

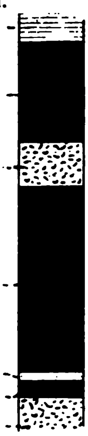
MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 82b.

Mine of Black Diamond Coal Company, section 9, Greenfield township, Lawrence county. The sample was taken from a fresh face, well under cover and measured 6 by 4 inches. The upper bench is less pure and varies much in thickness. The thin coal at the bottom is not mined and was rejected in sample. The latter was taken by D. D. Condit in November, 1906.

SECTION 82 b

	Ft.	In.
7. Gray shale,		
6. Coal, upper bench,	1	0
5. Clay,	0	5½
4. Coal, middle bench,	1	10½
3. Shale,	0	1
2. Coal, lower bench,	0	2
1. Clay, unmeasured,		



Chemical analysis and calorific value of Sample 82b:

Ultimate.		*Proximate.*	
Carbon	65.71	Moisture	8.08(a)
Hydrogen	5.48	Volatile Matter	37.53
Oxygen	15.47	Fixed carbon	45.87
Nitrogen	1.18	Ash	8.52
Sulphur	3.64		
Ash	8.52		
	100.00		100.00

Calorific value ....6,717 calories.

(a) Moisture in the air-dried sample from 2½ to 3 per cent.

MIDDLE KITTANNING COAL.

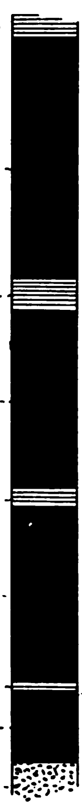
SAMPLE AND SECTION 83.

Mine of Luhrig Coal Company, section 4, Athens township, Athens county. The sample was 3½ inches wide and 5 inches deep, and was taken by B. A. Eisenlohr in July, 1902. Sample regarded first class.

The Upper Freeport or No. 7 coal lies about 75 feet higher and is 4 inches thick.

SECTION 83

	Ft.	In.
9. Slate,		
8. Coal, upper bench,	2	5
7. Parting,	0	4
6. Coal, upper bench,	1	9
5. Parting,	0	2½
4. Coal, middle bench,	1	9
3. Parting,	0	1
2. Coal, lower bench,	0	9
1. Fire clay,		



Chemical analysis and calorific value of Sample 83:

Ultimate.		*Proximate.*	
Carbon	69.22	Moisture	6.17
Hydrogen	5.43	Volatile Comb.	36.40
Oxygen	15.33	Fixed carbon	49.61
Nitrogen	1.30	Ash	7.82
Sulphur	0.90		
Ash	7.82		

Calorific value ....6,868 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 84.

Mine of Carbondale Coal Company, section 36, Waterloo township, Athens county. The sample is very fair. It measured 16 inches in width and 4½ inches in depth, and was taken by B. A. Eisenlohr in August, 1902.

SECTION 84

	Ft.	In.
10. Shale		
9. Rooster coal, rejected,	1	0
8. Hard shale,	0	6
7. Bone coal,	1	6
6. Coal, upper bench,	0	10
5. Parting,	0	4
4. Coal, middle bench,	2	4
3. Parting,	0	1
2. Coal, lower bench,	0	6
1. Fire clay,		

Chemical analysis and calorific value of Sample 84:

Ultimate.		*Proximate.*	
Carbon	69.21	Moisture	6.70
Hydrogen	5.49	Volatile Comb.	35.36
Oxygen	15.09	Fixed carbon	51.19
Nitrogen	1.18	Ash	6.75
Sulphur	2.28		
Ash	6.75		

Calorific value ....6,921 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 85.

Mine of J. P. Hardy, section 27 or 28, Waterloo township, Athens county. Sample very good, taken by B. A. Eisenlohr in July, 1902.

SECTION 85

	Ft.	In.
5. Shale,		
4. Coal, upper bench,	2	0
3. Shale,	0	1
2. Coal, lower bench,	0	8
1. Fire clay,		

Chemical analysis and calorific value of Sample 85:

Ultimate.		*Proximate.*	
Carbon	67.40	Moisture	6.80
Hydrogen	5.49	Volatile Comb.	36.90
Oxygen	15.55	Fixed carbon	48.25
Nitrogen	1.37	Ash	8.05
Sulphur	2.14		
Ash	8.05		

Calorific value ....6,794 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 86.

Mine of Continental Coal Company, section 4 or 5, Ward township, Hocking county. The sample measured 6½ by 5 inches and is excellent. Taken by B. A. Eisenlohr in July, 1902.

Chemical analysis and calorific value of Sample 86:

Ultimate.		*Proximate.*	
Carbon	70.05	Moisture	7.55
Hydrogen	5.52	Volatile Comb.	34.03
Oxygen	16.39	Fixed carbon	52.57
Nitrogen	1.42	Ash	5.85
Sulphur	0.77		
Ash	5.85		

Calorific value ....6,950 calories.

SECTION 86

	Ft.	In.
9. Slate,		
8. Coal, upper bench,	2	0
7. Parting,	0	3
6. Coal, middle bench,	3	0
5. Parting,	0	5
4. Coal, middle bench,	1	5
3. Parting,	0	1
2. Coal, lower bench,	2	1
1. Fire clay,		

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 87.

Mine of New Pittsburg Coal Company, section 7, Ward township, Hocking county. Sample, 12 by 5 inches in cross section, taken by B. A. Eisenlohr in July, 1902.

SECTION 87

	Ft.	In.
10. Shale,		
9. Splint coal,	1	6
8. Black shale,	1	2
7. Coal, upper bench,	1	3
6. Soft coal, rejected,	0	10
5. Shale,	0	4
4. Coal, middle bench,	1	6
3. Shale,	0	1
2. Coal, lower bench,	1	6
1. Fire clay,		

Chemical analysis and calorific value of Sample 87:

Ultimate.		*Proximate.*	
Carbon	71.04	Moisture	7.45
Hydrogen	5.53	Volatile Comb.	35.01
Oxygen	16.53	Fixed carbon	52.73
Nitrogen	1.43	Ash	4.81
Sulphur	0.66		
Ash	4.81		

Calorific value ....7,057 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 88.

Green & Hite Mine, Ward township, Hocking county. The sample was 8 by 5 inches in cross section and was a very good one. Taken by B. A. Eisenlohr in July, 1902.

SECTION 88

	Ft.	In.
12. Slate,		
11. Coal,	1	3
10. Bastard cannel,	0	4
9. Slate,	0	4
8. Bone coal,	0	4
7. Coal, upper bench,	1	10
6. Soft coal,	0	8
5. Parting,	0	3
4. Coal, middle bench,	2	0
3. Parting,	0	1
2. Coal, lower bench,	1	8
1. Fire clay,		

Chemical analysis and calorific value of Sample 88:

Ultimate.		*Proximate.*	
Carbon	70.58	Moisture	7.40
Hydrogen	5.55	Volatile Comb.	34.17
Oxygen	16.49	Fixed carbon	53.43
Nitrogen	1.32	Ash	5.00
Sulphur	1.06		
Ash	5.00		

Calorific value .... 7,027 calories.

MIDDLE KITTANNING COAL.

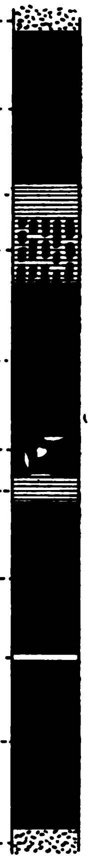
SAMPLE. AND SECTION 89.

Mine of Continental Coal Company, section 27, Dover township, Athens county. Sample 14 inches wide and 5 inches deep. Very good sample, taken by B. A. Eisenlohr in July, 1902.

This coal is reached by a shaft 117 feet deep. Lying about 80 feet above this coal, the No. 7 seam was found 3½ feet thick.

SECTION 89

	Ft.	In.
11. Soapstone,		
10. Coal,	1	6
9. Shale,	0	4
8. Bone coal,	0	8
7. Coal, upper bench,	1	6
6. Soft coal,	0	5
5. Shale,	0	3
4. Coal, middle bench,	1	6
3. Shale,	0	1
2. Coal, lower bench,	1	8
1. Fire clay,		



Chemical analysis and calorific value of Sample 89:

Ultimate.		*Proximate.*	
Carbon	69.32	Moisture	7.14
Hydrogen	5.56	Volatile Comb.	34.22
Oxygen	15.45	Fixed carbon	51.92
Nitrogen	1.30	Ash	6.72
Sulphur	1.65		
Ash	6.72		

Calorific value ....6,863 calories.

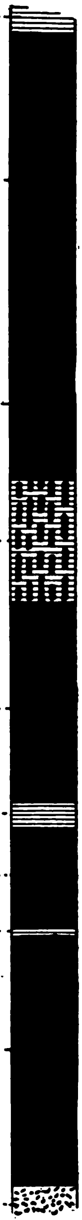
MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 90.

Continental Coal Company, Mine No. 4, section 8, Trimble township, Athens county. Coal reached by a shaft 135 feet deep. Sample 8 by 7 inches, taken by B. A. Eisenlohr in July, 1902.

SECTION 90

		Ft.	In.
10.	Slate,		
9.	Rooster coal,	3	0
8.	Cannel coal,	1	6
7.	Bone coal,	1	3
6.	Coal, upper bench,	2	0
5.	Parting,	0	3
4.	Coal, middle bench,	1	0
3.	Parting,	0	1
2.	Coal, lower bench,	2	6
1.	Fire clay,		



Chemical analysis and calorific value of Sample 90:

Ultimate.		*Proximate.*	
Carbon	69.46	Moisture	7.28
Hydrogen	5.45	Volatile Comb.	32.38
Oxygen	16.16	Fixed carbon	53.61
Nitrogen	1.34	Ash	6.73
Sulphur	0.86		
Ash	6.73		

Calorific value .... 6894 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 89a.

Mine of Canaanville Coal Company, Canaan township, Athens county. This is a shaft mine. 412 feet in depth. The sample was cut near the air shaft and measured 5 by 3 inches. The lower bench of the coal was wet. Sampled by D. D. Condit in November, 1907.

SECTION 89a

		Ft.	In.
9.	Shale, unmeasured,		
8.	Coal,	0	10
7.	Shale,	0	3
6.	Coal, upper bench,	1	7
5.	Shale,	0	2¾
4.	Coal, middle bench,	0	6½
3.	Bone coal,	0	1½
2.	Coal, lower bench,	2	4
1.	Clay, unmeasured,		

Chemical analysis and calorific value of Sample 89a:

Ultimate.		*Proximate.*	
Carbon	69.25	Moisture	6.36(a)
Hydrogen	5.40	Volatile	34.19
Oxygen	14.92	Fixed carbon	50.96
Nitrogen	1.43	Ash	8.49
Sulphur	0.51		
Ash	8.49		
	100.00		100.00

Calorific value ....6,919 calories.

(a) Moisture in the air-dried sampde from 2½ to 3 per cent.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 91.

S. C. C. Company, Mine No. 8, section 9, Monroe township, Perry county. Excellent sample 8 inches wide and 4 deep, made by B. A. Eisenlohr in July, 1902.

Chemical analysis and calorific value of Sample 91:

Ultimate.		*Proximate.*	
Carbon	70.30	Moisture	6.79
Hydrogen	5.49	Volatile Comb.	35.45
Oxygen	16.00	Fixed carbon	51.85
Nitrogen	1.30	Ash	5.91
Sulphur	1.00		
Ash	5.91		

Calorific value ....6,983 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 92.

E. E. Tharp's Mine, section 14, Pike township, Perry county. Sample 10 by 5 inches, and was taken by B. A. Eisenlohr in July, 1902. Sample very good.

Chemical analysis and calorific value of Sample 92:

Ultimate.		*Proximate.*	
Carbon	66.05	Moisture	5.25
Hydrogen	5.38	Volatile Comb.	38.85
Oxygen	14.10	Fixed carbon	46.04
Nitrogen	1.18	Ash	9.86
Sulphur	3.43		
Ash	9.86		

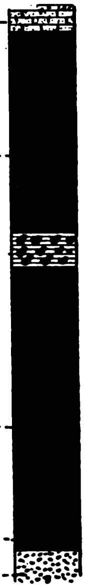
Calorific value ....6,773 calories.

SECTION 91

	Ft.	In.
6. Shale		
5. Top coal	3	0
4. Coal, upper bench	3	0
3. Bone coal	2	5
2. Coal, lower bench	2	4
1. Fire clay		

SECTION 92

	Ft.	In.
6. Sandstone,		
5. Coal, upper bench,	2	0
4. Pyrites,	0	4
3. Coal, lower bench,	2	8
2. Bottom coal,	0	2
1. Fire clay,		



MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 93.

National Fuel Company, Mine 34, section 3, Bearfield township, Perry county. Sample about 20 inches wide and 4 deep, taken by B. A. Eisenlohr in July, 1902.

SECTION 93

	Ft.	In.
7. Shale,		
6. Coal, upper bench,	0	8
5. Pyrites,		
4. Coal, middle bench,	0	6
3. Parting,	0	1
2. Coal, lower bench,	2	6
1. Fire clay,		

Chemical analysis and calorific value of Sample 93:

Ultimate.		*Proximate.*	
Carbon	65.43	Moisture	5.90
Hydrogen	5.26	Volatile Comb.	36.58
Oxygen	13.03	Fixed carbon	47.42
Nitrogen	1.22	Ash	10.10
Sulphur	4.96		
Ash	10.10		

Calorific value ....6,686 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 94.

Keystone Mine, No. 1, section 20 and 29, Harrison township, Perry county. Sample very good, cut from section 2 feet wide and 4 inches deep by B. A. Eisenlohr in July, 1902.

SECTION 94

	Ft.	In.
9. Soapstone,		
8. Bone coal,	0	8
7. Draw slate,	0	2
6. Coal, upper bench,	1	4
5. Parting,	0	1
4. Coal, middle bench,	0	7
3. Pyrites,	0	1
2. Coal, lower bench,	1	6
1. Fire clay,		

Chemical analysis and calorific value of Sample 94:

Ultimate.		*Proximate.*	
Carbon	69.77	Moisture	7.21
Hydrogen	5.60	Volatile Comb.	37.60
Oxygen	15.77	Fixed carbon	49.93
Nitrogen	1.26	Ash	5.26
Sulphur	2.34		
Ash	5.26		

Calorific value ....7,008 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 95.

Yost's Mine, section 18, Clayton township, Perry county. Sample about 21 by 7 inches, cut by B. A. Eisenlohr in July, 1902.

SECTION 95

	Ft.	In.
9. Soapstone,	6	0
8. Black shale,	1	1
7. Bone coal,	0	6
6. Coal, upper bench,	0	8
5. Parting,	0	¼
4. Coal, middle bench,	0	6
3. Parting,	0	3
2. Coal, lower bench,	1	6
1. Fire clay,		

Chemical analysis and calorific value of Sample 95:

Ultimate.		*Proximate.*	
Carbon	68.45	Moisture	6.72
Hydrogen	5.61	Volatile Comb.	38.30
Oxygen	15.58	Fixed carbon	48.34
Nitrogen	1.29	Ash	6.64
Sulphur	2.43		
Ash	6.64		

Calorific value ....6,903 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 96.

S. T. Jones' Mine, section 14, Newton township, Muskingum county. Sample 18 by 5 inches, cut by B. A. Eisenlohr in July, 1902. Seventy feet below this, another seam was observed with a blue fossiliferous limestone overlying it.

Chemical analysis and calorific value of Sample 96:

Ultimate.		*Proximate.*	
Carbon	65.88	Moisture	5.02
Hydrogen	5.29	Volatile Comb.	38.16
Oxygen	12.18	Fixed carbon	47.26
Nitrogen	1.12	Ash	9.56
Sulphur	5.97		
Ash	9.56		

Calorific value ....6,758 calories.

SECTION 96

	Ft.	In.
5. Bone coal,	0	8
4. Coal, upper bench,	1	10
3. Parting,	0	1
2. Coal, lower bench,	1	7
1. Fire clay,		

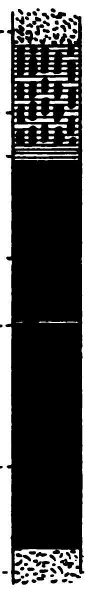
MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 97.

Mine of the New Crescent Mining Company, section 5, Harrison township, Perry county. Sample excellent, cut from a section 18 by 5 inches by B. A. Eisenlohr in July, 1902.

SECTION 97

	Ft.	In.
7. Soapstone,		
6. Bone coal,	1	0
5. Shale,	0	2
4. Coal, upper bench,	1	7
3. Parting,		
2. Coal, lower bench,	2	3
1. Fire clay,		



Chemcial analysis and calorific value of Sample 97:

Ultimate.		*Proximate.*	
Carbon	67.77	Moisture	5.70
Hydrogen	5.37	Volatile Comb.	38.83
Oxygen	13.85	Fixed carbon	47.02
Nitrogen	1.18	Ash	8.45
Sulphur	3.38		
Ash	8.45		

Calorific value ....6,851 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 98.

Mine of Hamilton & Wallace Coal Company, section 13, Harrison township, Perry county. Sample cut near the face of a new opening about 150 feet from mouth of the mine. Sample about 15 by 6 inches, cut by B. A. Eisenlohr in July, 1902.

SECTION 98

	Ft.	In.
9. Soapstone,		
8. Bone coal,	1	1
7. Shale,	0	2
6. Coal, upper bench,	0	6
5. Parting,	0	1
4. Coal, middle bench,	0	8
3. Parting,	0	1½
2. Coal, lower bench,	1	10
1. Fire clay,		

Chemical analysis and calorific value of Sample 98:

Ultimate.		*Proximate.*	
Carbon	68.06	Moisture	6.40
Hydrogen	5.49	Volatile Comb.	38.00
Oxygen	14.89	Fixed carbon	48.02
Nitrogen	1.26	Ash	7.58
Sulphur	2.72		
Ash	7.58		

Calorific value ....6,867 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 99.

Mine of Frank Lacey, Washington township, Muskingum county. Excellent sample cut from a section about 24 by 6 inches, by B. A. Eisenlohr in July, 1902.

SECTION 99

	Ft.	In.
6. Soapstone,		
5. Shale,	0	2
4. Coal, upper bench,	1	8
3. Pyrites,	0	2
2. Coal, lower bench,	0	7
1. Fire clay,		

Chemical analysis and calorific value of Sample 99:

Ultimate.		*Proximate.*	
Carbon	67.16	Moisture	5.44
Hydrogen	5.34	Volatile Comb.	39.15
Oxygen	13.27	Fixed carbon	46.13
Nitrogen	1.18	Ash	9.28
Sulphur	3.77		
Ash	9.28		

Calorific value .... 6,822 calories.

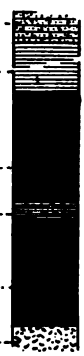
MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 100.

Mine of Wesley Wells, section 30 or 31, Harrison township, Muskingum county. Excellent sample cut from section about 22 by 6 inches, by B. A. Eisenlohr in August, 1902.

SECTION 100

	Ft.	In.
6. Sandstone,		
5. Shale,	15	0
4. Coal, upper bench,	1	1
3. Parting,	0	2
2. Coal, lower bench,	1	1
1. Fire clay,		



Chemical analysis and calorific value of Sample 100:

Ultimate.		*Proximate.*	
Carbon	67.71	Moisture	4.67
Hydrogen	5.38	Volatile Comb.	40.32
Oxygen	11.82	Fixed carbon	45.18
Nitrogen	1.16	Ash	9.83
Sulphur	4.10		
Ash	9.83		

Calorific value .... 6,873 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 101.

Mine of Walnut Hill Coal Company, section 13, Brush Creek township, Muskingum county. Excellent sample, about 13 by 7 inches, cut by B. A. Eisenlohr in August, 1902.

SECTION 101

	Ft.	In.
6. Sandstone,		
5. Shale,	20	0
4. Coal, upper bench,	1	7
3. Parting,		
2. Coal, lower bench,	2	0
1. Fire clay,		

Chemical analysis and calorific value of Sample 101:

Ultimate.		*Proximate.*	
Carbon	65.74	Moisture	5.08
Hydrogen	5.32	Volatile Comb.	39.75
Oxygen	12.49	Fixed carbon	45.40
Nitrogen	1.14	Ash	9.77
Sulphur	5.54		
Ash	9.77		

Calorific value .... 6,802 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 102.

Mine of E. R. Birkhimer, Madison township, Muskingum county. Excellent sample, about 24 by 5 inches, and cut by B. A. Eisenlohr in August, 1902.

SECTION 102

	Ft.	In.
5. Soapstone,	3	0
4. Coal, upper bench,	2	1
3. Parting,	0	1½
2. Coal, lower bench,	0	7
1. Fire clay,		

Chemical analysis and calorific value of Sample 102:

Ultimate.		*Proximate.*	
Carbon	66.69	Moisture	4.75
Hydrogen	5.35	Volatile Comb.	39.88
Oxygen	12.05	Fixed carbon	46.09
Nitrogen	1.28	Ash	9.28
Sulphur	5.35		
Ash	9.28		

Calorific value ....6,854 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 103.

Mine of E. U. Farrell, Madison township, Muskingum county. Excellent sample, about 20 by 5 inches, and cut by B. A. Eisenlohr in August, 1902.

SECTION 103

	Ft.	In.
6. Sandstone,		
5. Shale,		
4. Coal, upper bench,	2	2
3. Parting,	0	2
2. Coal, lower bench,	0	8
1. Fire clay,		

Chemical analysis and calorific value of Sample 103:

Ultimate.		*Proximate.*	
Carbon	69.58	Moisture	4.62
Hydrogen	5.47	Volatile Comb.	40.95
Oxygen	12.58	Fixed carbon	47.85
Nitrogen	1.30	Ash	6.58
Sulphur	4.49		
Ash	6.58		

Calorific value .... 7,126 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 104.

Mine of A. W. Smith, Muskingum township, Muskingum county. The sample was cut from a section, about 18 by 5 inches, by B. A. Eisenlohr in August, 1902. A little mud fell into the coal, hence the sample is not first class.

SECTION 104

	Ft.	In.
8. Shale,		
7. False roof (dirty coal),		
6. Coal, upper bench,	1	7
5. Pyrites,	0	3
4. Coal, middle bench,	0	6
3. Parting,	0	2
2. Coal, lower bench,	1	6
1. Fire clay,		

Chemical analysis and calorific value of Sample 104:

Ultimate.		*Proximate.*	
Carbon	70.54	Moisture	5.55
Hydrogen	5.57	Volatile Comb.	40.27
Oxygen	13.77	Fixed carbon	48.95
Nitrogen	1.26	Ash	5.23
Sulphur	3.63		
Ash	5.23		

Calorific value .... 7,191 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 105.

Mine of A. W. Marshall, section 17, Jackson township, Coshocton county. Very good sample cut from section about 12 by 5 inches by B. A. Eisenlohr in August, 1902. About 20 feet lower is another coal, 4 feet thick, and about 60 feet below the No. 6 seam is still another coal, 18 inches thick. The latter is covered with a fossiliferous and the former with a non-fossiliferous limestone.

SECTION 105

	Ft.	In.
6. Sandstone,		
5. Shale,	0	8
4. Coal, upper bench,	2	9
3. Parting,	0	1
2. Coal, lower bench,	0	11
1. Fire clay,		

Chemical analysis and calorific value of Sample 105:

Ultimate.		*Proximate.*	
Carbon	69.29	Moisture	5.32
Hydrogen	5.50	Volatile Comb.	40.93
Oxygen	13.45	Fixed carbon	47.45
Nitrogen	1.24	Ash	6.30
Sulphur	4.22		
Ash	6.30		

Calorific value ....7,086 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 106.

Mine of G. W. Levengood, section 20, Clark township, Coshocton county. Where sample was cut the lower bench is wanting. Excellent sample about 18 by 6 inches and cut by B. A. Eisenlohr in August, 1902.

SECTION 106

	Ft.	In.
4. Sandstone,		
3. Shale,	3	0
2. Coal,	2	5
1. Fire clay,		

Chemical analysis and calorific value of Sample 106:

Ultimate.		*Proximate.*	
Carbon	69.59	Moisture	5.30
Hydrogen	5.50	Volatile Comb.	39.08
Oxygen	13.92	Fixed carbon	49.47
Nitrogen	1.12	Ash	6.15
Sulphur	3.72		
Ash	6.15		

Calorific value .... 7,084 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 107.

Mine of E. McClure, Keene township, Coshocton county. Sample very good, cut from a section about 24 by 5 inches by B. A. Eisenlohr in August, 1902.

SECTION 107

	Ft.	In.
3. Shale,		
2. Coal,	2	1
1. Fire clay,		

Chemical analysis and calorific value of Sample 107:

Ultimate.		*Proximate.*	
Carbon	70.90	Moisture	5.40
Hydrogen	5.58	Volatile Comb.	39.92
Oxygen	14.02	Fixed carbon	49.60
Nitrogen	1.24	Ash	5.08
Sulphur	3.18		
Ash	5.08		

Calorific value .... 7,194 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 108.

Mine of Best Coal Company, Franklin township, Coshocton county. Sample fine, cut from section about 12 by 4 inches by B. A. Eisenlohr in August, 1902.

SECTION 108

	Ft.	In.
5. Shale,		
4. Coal, upper bench,	2	10
3. Parting,	0	2
2. Coal, lower bench,	1	4
1. Fire clay,		

Chemical analysis and calorific value of Sample 108:

Ultimate.		*Proximate.*	
Carbon	71.42	Moisture	4.33
Hydrogen	5.41	Volatile Comb.	41.11
Oxygen	12.36	Fixed carbon	48.97
Nitrogen	1.22	Ash	5.59
Sulphur	4.00		
Ash	5.59		

Calorific value ....7,269 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 109.

Mine of Charles Fillomlee, Virginia township, Coshocton county. Coal contains numerous pyrite and soot streaks. Sample rather dirty. Cut from a section about 24 by 5 inches by B. A. Eisenlohr in August, 1902.

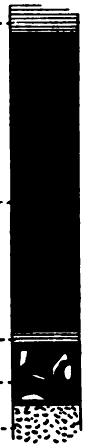
Chemical analysis and calorific value of Sample 109:

Ultimate.		*Proximate.*	
Carbon	69.49	Moisture	5.12
Hydrogen	5.45	Volatile Comb.	38.99
Oxygen	12.97	Fixed carbon	48.87
Nitrogen	1.20	Ash	7.02
Sulphur	3.87		
Ash	7.02		

Calorific value ....7,066 calories.

SECTION 109

	Ft.	In.
5. Shale,		
4. Coal, upper bench,	3	0
3. Parting,	0	1½
2. Coal, lower bench,	0	7
1. Fire clay,		



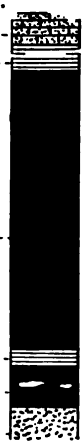
MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 110.

Mine of J. P. Patton, Coshocton county. Good sample cut from a section about 18 by 5 inches by B. A. Eisenlohr in August, 1902.

SECTION 110

	Ft.	In.
6. Sandstone,		
5. Shale,	0	3
4. Coal, upper bench,	2	9
3. Parting,	0	2
2. Coal, lower bench,	0	5
1. Fire clay,		



Chemical analysis and calorific value of Sample 110:

Ultimate.		*Proximate.*	
Carbon	61.59	Moisture	5.60
Hydrogen	4.95	Volatile Comb.	34.69
Oxygen	14.23	Fixed carbon	46.43
Nitrogen	1.08	Ash	13.28
Sulphur	4.87		
Ash	13.28		

Calorific value ....6,222 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 111.

Mine of W. J. Young, section 24, Linton township, Coshocton county. Fair sample cut from a section about 25 by 5 inches by B. A. Eisenlohr in August, 1902.

SECTION 111

	Ft.	In.
7. Sandstone,		
6. Shale,	0	10
5. Dirty coal,	0	5
4. Coal, upper bench,	2	6
3. Parting,	0	2
2. Coal, lower bench,	0	10
1. Fire clay,		

Chemical analysis and calorific value of Sample 111:

Ultimate.		*Proximate.*	
Carbon	71.34	Moisture	4.37
Hydrogen	5.56	Volatile Comb.	40.97
Oxygen	12.85	Fixed carbon	49.30
Nitrogen	1.28	Ash	5.36
Sulphur	3.61		
Ash	5.36		

Calorific value ....7,247 calories.

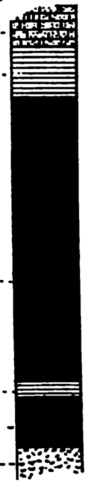
MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 112.

Mine of Peter Hammersly, section 2, Linton township, Coshocton county. Sample not very good owing to bad condition of mine. Cut from section about 16 by 7 inches by B. A. Eisenlohr in August, 1902.

SECTION 112

	Ft.	In.
6. Sandstone,		
5. Shale,		
4. Coal, upper bench,	2	10
3. Parting,	0	2
2. Coal, lower bench,	0	6
1. Fire clay,		



Chemical analysis and calorific value of Sample 112:

Ultimate.		*Proximate.*	
Carbon	63.08	Moisture	10.93
Hydrogen	5.37	Volatile Comb.	34.00
Oxygen	21.73	Fixed carbon	48.43
Nitrogen	1.15	Ash	6.64
Sulphur	2.03		
Ash	6.64		

Calorific value ......6,133 calories.

SAMPLE AND SECTION 113.

Mine of Peter Henricks, section 20, Oxford township, Coshocton county. New mine, sample taken about 225 feet from entrance. Coal has numerous pyrite bands. Good sample cut from section, about 24 by 5 inches, by B. A. Eisenlohr in August, 1902.

SECTION 113

	Ft.	In.
6. Sandstone,		
5. Shale,		
4. Coal, upper bench,	1	8
3. Pyrites,	0	1½
2. Coal, lower bench,	0	7
1. Fire clay,		

Chemical analysis and calorific value of Sample 113:

Ultimate.		*Proximate.*	
Carbon	72.65	Moisture	4.44
Hydrogen	5.53	Volatile Comb.	40.71
Oxygen	12.48	Fixed carbon	50.40
Nitrogen	1.35	Ash	4.45
Sulphur	3.54		
Ash	4.45		

Calorific value ....7,351 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 114.

Mine of Young Brothers, section 1, Adams township, Coshocton county. Coal has numerous pyrite layers which appear and disappear. Sample not the best. Cut from section about 30 by 4 inches, by B. A. Eisenlohr in August, 1902.

SECTION 114

	Ft.	In.
4. Sandstone,		
3. Shale,	20	0
2. Coal,	2	4
1. Fire clay,		

Chemical analysis nd calorific value of Sample 114:

Ultimate.		*Proximate.*	
Carbon	67.51	Moisture	4.58
Hydrogen	5.40	Volatile Comb.	39.18
Oxygen	11.74	Fixed carbon	47.49
Nitrogen	1.24	Ash	8.75
Sulphur	5.36		
Ash	8.75		

Calorific value ....6,878 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 115.

Mine of A. J. Hawk, Jefferson township, Tuscarawas county. Sample not satisfactory. Eight inches of coal were left at the top. Sampled by B. A. Eisenlohr in August, 1902.

SECTION 115

	Ft.	In.
4. Sandstone,		
3. Shale,		
2. Coal,	2	8
1. Fire clay,		

Chemical ahalysis and calorific value of Sample 115:

Ultimate.		*Proximate.*	
Carbon	71.08	Moisture	4.72
Hydrogen	5.53	Volatile Comb.	40.30
Oxygen	12.55	Fixed carbon	49.51
Nitrogen	1.32	Ash	5.47
Sulphur	4.05		
Ash	5.47		

Calorific value .... 7,199 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 116.

Mine of Troyer & Co., Bucks township, Tuscarawas county. Coal has irregular streaks of pyrite. Sample excellent. Cut from section about 16 by 4 inches, by B. A. Eisenlohr in August, 1902.

SECTION 116

	Ft.	In.
4. Sandstone,		
3. Shale,	15	0
2. Coal,	2	11
1. Fire clay,		

Chemical analysis and calorific value of Sample 116:

Ultimate.		*Proximate.*	
Carbon	70.12	Moisture	5.19
Hydrogen	5.59	Volatile Comb.	40.79
Oxygen	13.51	Fixed carbon	48.15
Nitrogen	1.36	Ash	5.87
Sulphur	3.55		
Ash	5.87		

Calorific value .... 7,122 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 117.

Mine of John S. Baker, section 4, Crawford township. Coshocton county. Good sample cut from section about 14 by 6 inches, by B. A. Eisenlohr in August, 1902.

SECTION 117

	Ft.	In.
6. Soapstone,		
5. Shale,		
4. Coal, upper bench,	2	6
3. Parting,	0	2
2. Coal, lower bench,	0	7
1. Fire clay,		

Chemical analysis and calorific value of Sample 117:

Ultimate.		*Proximate.*	
Carbon	64.78	Moisture	4.70
Hydrogen	5.23	Volatile Comb.	39.20
Oxygen	11.98	Fixed carbon	44.81
Nitrogen	1.12	Ash	11.29
Sulphur	5.60		
Ash	11.29		

Calorific value .... 6,594 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 118.

Mine of Adam Miller, section 5, White Eyes township, Coshocton county. Fine sample. Cut from section about 15 by 5 inches, by B. A. Eisenlohr in August, 1902.

SECTION 118

	Ft.	In.
7. Sandstone,		
6. Soapstone,		
5. Shale,	0	6
4. Coal, upper bench,	2	9
3. Parting,	0	1½
2. Coal, lower bench,	0	11
1. Fire clay,		

Chemical analysis and calorific value of Sample 118:

Ultimate.		*Proximate.*	
Carbon	67.41	Moisture	5.32
Hydrogen	5.32	Volatile Comb.	37.39
Oxygen	13.13	Fixed carbon	48.69
Nitrogen	1.18	Ash	8.60
Sulphur	4.36		
Ash	8.60		

Calorific value .... 6,828 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 119.

Mine of Michael Zalmer, section 24, Walnut Creek township, Holmes county. The coal in this mine is more or less red and weathered. Sample cut from section about 14 by 7 inches, by B. A. Eisenlohr in August, 1902.

Chemical analysis and calorific value of Sample 119:

Ultimate.		*Proximate.*	
Carbon	70.62	Moisture	7.31
Hydrogen	5.42	Volatile Comb.	34.92
Oxygen	17.31	Fixed carbon	53.56
Nitrogen	1.44	Ash	4.21
Sulphur	1.00		
Ash	4.21		

Calorific value .... 6,952 calories.

SECTION 119

	Ft.	In.
3. Shale,		
2. Coal,	2	6
1. Fire clay,		

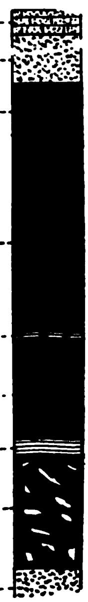
MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 120.

Mine of Lewis McFarland, section 24, White Eyes township, Coshocton county. Good sample cut from section about 14 by 4 inches, by B. A. Eisenlohr in August, 1902.

SECTION 120

	Ft.	In.
9. Sandstone,		
8. Soapstone, 5′—0″ to	12	0
7. False roof (dirty coal),	0	6
6. Coal, upper bench,	2	0
5. Pyrites,	0	1
4. Coal, middle bench,	1	0
3. Parting,	0	2
2. Coal, lower bench,	1	2
1. Fire clay,		



Chemical analysis and calorific value of Sample 120:

Ultimate.		*Proximate.*	
Carbon	70.94	Moisture	4.50
Hydrogen	5.53	Volatile Comb.	38.73
Oxygen	12.63	Fixed carbon	50.80
Nitrogen	1.30	Ash	5.97
Sulphur	3.63		
Ash	5.97		

Calorific value ....7,173 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 121.

Mine of Timothy Sewell, Dover township, Tuscarawas county. Coal quite free from pyrite except in the parting. Good sample, cut from section about 12 by 7 inches, by B. A. Eisenlohr in August, 1902.

SECTION 121

	Ft.	In.
7. Sandstone,		
6. Shale,	12	0
5. Bone coal,	0	5
4. Coal, upper bench,	2	5
3. Parting,	0	1
2. Coal, lower bench,	1	0
1. Fire clay,		

Chemical analysis and calorific value of Sample 121:

Ultimate.		*Proximate.*	
Carbon	72.13	Moisture	3.52
Hydrogen	5.41	Volatile Comb.	40.25
Oxygen	12.00	Fixed carbon	50.22
Nitrogen	1.28	Ash	6.01
Sulphur	3.17		
Ash	6.01		

Calorific value ....7,297 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 122.

Mine of Joseph Shilling, Dover township, Tuscarawas county. Good sample, cut from section about 14 by 6 inches, by B. A. Eisenlohr in August, 1902.

SECTION 122

	Ft.	In.
3. Coal, upper bench,	2	3
2. Pyrites,	0	2
1. Coal, lower bench,	1	3

Chemical analysis and calorific value of Sample 122:

Ultimate.		*Proximate.*	
Carbon	67.54	Moisture	4.94
Hydrogen	5.14	Volatile Comb.	36.20
Oxygen	12.33	Fixed carbon	49.36
Nitrogen	1.30	Ash	9.50
Sulphur	4.19		
Ash	9.50		

Calorific value ....6,856 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 123.

Mine of East Goshen Coal Company, section 12, Goshen township, Tuscarawas county. Coal has considerable pyrite, especially in the lower and upper benches. Good sample cut from section about 14 by 4 inches. Sampled by B. A. Eisenlohr in August, 1902.

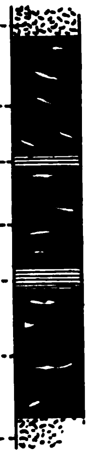
Chemical analysis and calorific value of Sample 123:

Ultimate.		*Proximate.*	
Carbon	70.26	Moisture	3.51
Hydrogen	5.45	Volatile Comb.	41.60
Oxygen	10.82	Fixed carbon	47.20
Nitrogen	1.22	Ash	7.69
Sulphur	4.56		
Ash	7.69		

Calorific value ....7,153 calories.

SECTION 123

	Ft.	In.
7. Soapstone,		
6. Coal, upper bench,	2	2
5. Parting,	0	1½
4. Coal, middle bench,	1	0
3. Parting,	0	2½
2. Coal, lower bench,	1	3
1. Fire clay,		



MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 124.

Mine of Medville & Goshen Coal Company, Warwick township, Tuscarawas county. Sample fair, cut from section about 12 by 5 inches, by B. A. Eisenlohr in August, 1902.

SECTION 124

	Ft.	In.
8. Soapstone,		
7. Bone coal,	0	9
6. Coal, upper bench,	1	9
5. Parting,	0	½
4. Coal, middle bench,	0	7
3. Parting,	0	2½
2. Coal, lower bench,	1	8
1. Fire clay,		

Chemical analysis and calorific value of Sample 124:

Ultimate.		*Proximate.*	
Carbon	72.45	Moisture	4.10
Hydrogen	5.57	Volatile Comb.	41.64
Oxygen	12.10	Fixed carbon	49.05
Nitrogen	1.42	Ash	5 21
Sulphur	3.25		
Ash	5.21		

Calorific value .... 7,331 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 125.

Mine of Valentine Lieser, section 24, Lawrence township, Tuscarawas county. Sample contains some dirt and so is not satisfactory. Was cut from a section about 18 by 4 inches, by B. A. Eisenlohr in August, 1902.

SECTION 125

	Ft.	In.
8. Sandstone,		
7. Shale,	17	0
6. Coal, upper bench,	2	1
5. Pyrites,	0	½
4. Coal, middle bench,	0	5
3. Parting,	0	½
2. Coal, lower bench,	0	5
1. Fire clay,		

Chemical analysis and calorific value of Sample 125:

Ultimate.		*Proximate.*	
Carbon	67.59	Moisture	4.69
Hydrogen	5.30	Volatile Comb.	39.57
Oxygen	12.11	Fixed carbon	46.68
Nitrogen	1.24	Ash	9.06
Sulphur	4.70		
Ash	9.06		

Calorific value .... 6,881 calories.

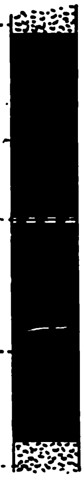
MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 126.

Mine of Tuscarawas C. & I. Company, near center of Sandy township, Tuscarawas county. Good sample cut from section about 19 by 5 inches. Sampled by B. A. Eisenlohr in August, 1902.

SECTION 126

	Ft.	In.
5. Soapstone,		
4. Coal, upper bench,	1	10
3. Pyrites,	0	1
2. Coal, lower bench,	2	2
1. Fire clay,		



Chemical analysis and calorific value of Sample 126:

Ultimate.		*Proximate.*	
Carbon	70.45	Moisture	4.92
Hydrogen	5.40	Volatile Comb.	38.13
Oxygen	12.92	Fixed carbon	49.91
Nitrogen	1.28	Ash	7.04
Sulphur	2.91		
Ash	7.04		

Calorific value ....7,082 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 127.

Mine of Somerdale Coal Company, section 9, Fairfield township, Tuscarawas county. Good sample, cut from section about 10 by 5 inches. Sampled by B. A. Eisenlohr in August, 1902.

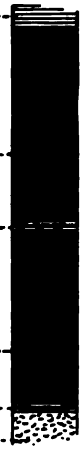
Chemical analysis and calorific value of Sample 127:

Ultimate.		*Proximate.*	
Carbon	70.80	Moisture	4.66
Hydrogen	5.48	Volatile Comb.	39.25
Oxygen	12.94	Fixed carbon	49.87
Nitrogen	1.28	Ash	6.22
Sulphur	3.28		
Ash	6.22		

Calorific value ....7,097 calories.

SECTION 127

		Ft.	In.
6.	Shale,	10	0
5.	Coal, upper bench,	1	11
4.	Pyrites,	0	1
3.	Coal, lower bench,	1	9
2.	Pyrites,	0	1
1.	Fire clay,		



MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 128.

Mine of Jacob Groh, section 17, Auburn township, Tuscarawas county. Top coal is always rejected. The lower bench contains occasional pyrite nuggets, which are always rejected. Excellent sample, cut from section about 16 by 5 inches, by B. A. Eisenlohr in September, 1902.

SECTION 128

		Ft.	In.
9.	Slate,		
8.	Top coal,	0	2½
7.	Shale,	0	2
6.	Coal, upper bench,	2	6
5.	Parting,	0	1
4.	Coal, middle bench,	0	5
3.	Pyrites,	0	2
2.	Coal, lower bench,	0	5
1.	Fire clay,		

Chemical analysis and calorific value of Sample 128:

		Proximate.	
Carbon	69.39	Moisture	4.30
Hydrogen	5.41	Volatile Comb.	40.07
Oxygen	12.32	Fixed carbon	48.00
Nitrogen	1.28	Ash	7.63
Sulphur	3.97		
Ash	7.63		

Calorific value .... 7,001 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 129.

Mine of American Sheet Steel Company, Union township, Tuscarawas county. Lower and middle benches are not defined throughout but frequently run together. The mine was muddy and some dirt may have gotten in the coal. Sample cut from a section about 15 by 4 inches, by B. A. Eisenlohr in September, 1902.

SECTION 129

	Ft.	In.
8. Sandstone,		
7. Soapstone,	3	0
6. Coal, upper bench,	2	0
5. Pyrites,	0	2
4. Coal, middle bench,	1	0
3. Parting,	0	½
2. Coal, lower bench,	0	11
1. Fire clay,		

Chemical analysis and calorific value of Sample 129:

Ultimate.		*Proximate.*	
Carbon	72.30	Moisture	3.81
Hydrogen	5.41	Volatile Comb.	38.71
Oxygen	11.68	Fixed carbon	51.47
Nitrogen	1.36	Ash	6.01
Sulphur	3.24		
Ash	6.01		

Calorific value .... 7,306 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 130.

Mine of Cyrus Kilpatrick, Mill township, Tuscarawas county. The sulphur band is regular but the other partings irregular. Excellent sample cut from section about 15 by 5 inches, by B. A. Eisenlohr in September, 1902.

SECTION 130

	Ft.	In.
7. Bastard rock,		
6. Coal,	0	6
5. Parting,	0	½
4. Coal, middle bench,	1	4
3. Pyrites,	0	2
2. Coal, lower bench,	1	2
1. Fire clay,		

Chemical analysis and calorific value of Sample 130:

Ultimate.		*Proximate.*	
Carbon	70.31	Moisture	3.78
Hydrogen	5.26	Volatile Comb.	38.27
Oxygen	10.96	Fixed carbon	49.53
Nitrogen	1.22	Ash	8.42
Sulphur	3.83		
Ash	8.42		

Calorific value ....7,101 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 131.

Mine of Solomon Stocker, near Gnadenhutten, Tuscarawas county. The dirty coal above the upper bench was rejected. Generally it is not mined. Good sample cut from section about 18 by 5 inches, by B. A. Eisenlohr in September, 1902.

Chemical analysis and calorific value of Sample 131:

Ultimate.		*Proximate.*	
Carbon	68.77	Moisture	3.41
Hydrogen	5.23	Volatile Comb.	39.73
Oxygen	10.44	Fixed carbon	47.48
Nitrogen	1.30	Ash	9.38
Sulphur	4.88		
Ash	9.38		

Calorific value ....6,971 calories.

SECTION 131

	Ft.	In.
8. Shale,		
7. Dirty coal,	0	9
6. Coal, upper bench,	2	4
5. Pyrites,	0	1
4. Coal, middle bench,	0	9
3. Pyrites,	0	2
2. Coal, lower bench,	0	4
1. Fire clay,		

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 132.

Mine of Somers Coal Company, near Sherrodsville, Carroll county. Coal reached by a shaft 80 feet deep. Excellent sample cut from section about 20 by 3 inches. Sampled by B. A. Eisenlohr in September, 1902.

SECTION 132

	Ft.	In.
5. Shale,		
4. Coal, upper bench,	1	8
3. Pyrites,	0	1½
2. Coal, lower bench,	2	4
1. Fire clay,		

Chemical analysis and calorific value of Sample 132:

Ultimate.		*Proximate.*	
Carbon	71.99	Moisture	3.76
Hydrogen	5.36	Volatile Comb.	39.11
Oxygen	11.40	Fixed carbon	50.34
Nitrogen	1.40	Ash	6.79
Sulphur	3.06		
Ash	6.79		

Calorific value .... 7,238 calories.

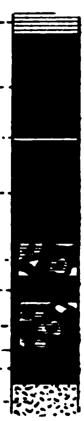
MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 133.

Mine of Jacob Stonebrook, near Newcomerstown, Tuscarawas county. Coal is quite dirty. Sample excellent. Cut from section about 20 by 4 inches, by B. A. Eisenlohr in September, 1902.

SECTION 133

	Ft.	In.
9. Shale,		
8. Coal,	0	12
7. Parting,	0	½
6. Coal,	1	0
5. Dirty coal and pyrites,	0	4
4. Coal,	0	3
3. Coal and pyrites,	0	6
2. Coal,	0	4
1. Fire clay,		



Chemical analysis and calorific value of Sample 133:

Ultimate.		*Proximate.*	
Carbon	70.02	Moisture	3.45
Hydrogen	5.30	Volatile Comb.	40.02
Oxygen	10.53	Fixed carbon	48.86
Nitrogen	1.26	Ash	7.67
Sulphur	5.22		
Ash	7.67		

Calorific value .... 7,135 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 134.

West Goshen Mine, York township, Tuscarawas county. Coal dirty, especially the middle bench. Lower parting sometimes absent. Sample excellent. Cut from section about 14 by 4 inches, by B. A. Eisenlohr in September, 1902.

SECTION 134

	Ft.	In.
7. Shale,		
6. Coal, upper bench,	2	7
5. Parting,	0	2
4. Coal, middle bench,	0	7
3. Parting,	0	2
2. Coal, lower bench,	1	5
1. Fire clay,		

Chemical analysis and calorific value of Sample 134:

Ultimate.		*Proximate.*	
Carbon	71.13	Moisture	3.18
Hydrogen	5.50	Volatile Comb.	43.56
Oxygen	11.04	Fixed carbon	46.33
Nitrogen	1.28	Ash	6.93
Sulphur	4.12		
Ash	6.93		

Calorific value ....7,305 calories.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 135.

Mine of Whitacre Fire-proofing Company, Waynesburg, Tuscarawas county. Sample cut from a fresh face well under the hill. The coal was wet and appeared inferior from top to bottom. Sampled by D. D. Condit in December, 1907. The clay below the coal is used in making the fire-proofing. It is removed first and then the coal shot down.

Chemical analysis and calorific value of Sample 135:

Ultimate.		*Proximate.*	
Carbon	68.94	Moisture	6.66(a)
Hydrogen	5.37	Volatile Matter	36.24
Oxygen	13.61	Fixed carbon	48.88
Nitrogen	1.20	Ash	8.22
Sulphur	2.66		
Ash	8.22		
	100.00		100.00

Calorific value ....6,977 calories.

(a) Moisture in the air-dried sample from 2½ to 3 per cent.

SECTION 135

	Ft.	In.
5. Shale,		
4. Coal,	1	1
3. Clay and pyrites,	1	1½
2. Coal,	1	8½
1. Fire clay,		

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 136.

Mine of J. W. Stout, Alliance, Stark county. Sample consists of a section 6 by 4 inches and was cut by D. D. Condit in December, 1907.

SECTION 136

	Ft.	In.
8. Shale,		
7. Bone coal,	0	1
6. Coal,	0	4½
5. Pyrites,	0	½
4. Coal,	0	5
3. Pyrites, persistent,	0	1½
2. Coal,	1	9
1. Fire clay,		

Chemical analysis and calorific value of Sample 136:

Ultimate.		*Proximate.*	
Carbon	71.82	Moisture	5.99(a)
Hydrogen	5.56	Volatile Matter	39.05
Oxygen	12.86	Fixed carbon	50.14
Nitrogen	1.33	Ash	4.82
Sulphur	3.61		
Ash	4.82		
	100.00		100.00

Calorific value .... 7,314 calories.

(a) Moisture in the air-dried sample from 2½ to 3 per cent.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 137.

Mine of W. J. Blackford at mouth of Dry Run, East Liverpool, Columbiana county. Sample consists of a section 7 by 4 inches and was cut by D. D. Condit in December, 1907.

SECTION 137

	Ft.	In.
6. Shale,		
5. Dirty coal,	0	4
4. Coal,	1	6
3. Shale,	0	3
2. Impure coal,	0	4
1. Fire clay,		

Chemical analysis and calorific value of Sample 137:

Ultimate.		*Proximate.*	
Carbon	77.06	Moisture	3.60(a)
Hydrogen	5.46	Volatile Matter	36.16
Oxygen	9.74	Fixed carbon	55.64
Nitrogen	1.38	Ash	4.60
Sulphur	1.76		
Ash	4.60		
	100.00		100.00

Calorific value ....7,789 calories.

(a) Moisture in the air-dried sample about 2%.

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 138.

Mine of the Somerdale Coal Company, Somerdale, Tuscarawas county. Coal rather moist. Sample consists of a section 6 by 3 inches and was cut by D. D. Condit in December, 1907.

Chemical analysis and calorific value of Sample 138:

Ultimate.		*Proximate.*	
Carbon	71.29	Moisture	7.15(a)
Hydrogen	5.64	Volatile Matter	38.34
Oxygen	14.66	Fixed carbon	49.95
Nitrogen	1.23	Ash	4.56
Sulphur	2.62		
Ash	4.56		
	100.00		100.00

Calorific value ....7,194 calories.

(a) Moisture in the air-dried sample from 2½ to 3 per cent.

SECTION 138

	Ft.	In.
8. Shale with nodular ore,		
7. Bone coal and pyrites,	0	9
6. Coal,	1	1
5. Coal and pyrites,	0	6
4. Coal,	0	9
3. Clay and pyrites,	0	1
2. Coal,	0	8½
1. Fire clay,		

MIDDLE KITTANNING COAL.

SAMPLE AND SECTION 139.

McGinty mine, section 24, Nimishillen township, Stark county. Sample consists of a section 6 by 3 inches. The clay below the coal is also used.

SECTION 139

	Ft.	In.
6. Sandstone,		
5. Shale and nodular ore,	2	0
4. Coal,	0	10
3. Clay,	0	1½
2. Coal,	1	10
1. Fire clay,		

Chemical analysis and calorific value of Sample 139:

Ultimate.		*Proximate.*	
Carbon	66.92	Moisture	5.65
Hydrogen	5.29	Volatile Matter	38.51
Oxygen	12.39	Fixed carbon	45.76
Nitrogen	1.19	Ash	10.08
Sulphur	4.13		
Ash	10.08		
	100.00		100.00

Calorific value .... 6,868 calories.

(a) Moisture in the air-dried sample from 2½ to 3 per cent.

CHAPTER VII.

THE UPPER FREEPORT OR NO. 7 COAL.[1]

This seam like the Middle Kittanning can be traced across the state. It is much less persistent in thickness, however, than the Middle Kittanning seam, and is of correspondingly smaller value. The best deposits of the coal are found in the eastern and northeastern parts of the state. The Cambridge field which included parts of Guernsey and Noble counties forms one of the most valuable coal deposits in the state, its output in 1906 being in excess of 3,000,000 tons.

The analyses reported in this work, however, do not include the Cambridge field or the territory to the northeast and hence no further reference will be made to it.

In the northeastern part of Lawrence and the adjacent part of Gallia county is a deposit of importance. It is known as the Waterloo field from the little village of that name. Thus far the coal has been mined for local use only, owing to the lack of transportation facilities. When the latter is provided the field may become a large producer. The sections and analyses which follow correctly show its thickness, structure and composition.

Between this field and the Cambridge the seam is irregular. Occasionally banks are opened by farmers, but mines for shipment are very scarce.

UPPER FREEPORT COAL.

SAMPLE AND SECTION 140.

Cooper's Mine, section 24 or 25, Symmes township, Lawrence county. Sample was taken from lower bench only. Good sample. Taken by E. E. Somermeier in August, 1901.

Chemical analysis and calorific value of Sample 140:

Ultimate.		*Proximate.*	
Carbon	67.09	Moisture	7.13
Hydrogen	5.33	Volatile Comb.	33.65
Oxygen	16.08	Fixed carbon	50.31
Nitrogen	1.28	Ash	8.91
Sulphur	1.31		
Ash	8.91		

Calorific value ....6,716 calories.

[1] For method of sampling see Chapter IX.

SECTION 140

	Ft.	In.
7. Clay and shale,		
6. Coal, upper bench,	1	3
5. Clay,	0	5
4. Coal,	0	3
3. Shale,	0	7
2. Coal, lower bench,	4	0
1. Fire clay,		

UPPER FREEPORT COAL.

SAMPLE AND SECTION 141.

Mine of G. W. Peach, section 23, Symmes township, Lawrence county. Sample includes both benches. Sampled by E. E. Somermeier in August, 1901.

Chemical analysis and calorific value of Sample 141:

Ultimate.		*Proximate.*	
Carbon	66.88	Moisture	8.77
Hydrogen	5.32	Volatile Comb.	31.70
Oxygen	17.08	Fixed carbon	50.82
Nitrogen	1.25	Ash	8.71
Sulphur	0.76		
Ash	8.71		

Calorific value ....6,586 calories.

SECTION 141

	Ft.	In.
3. Coal, upper bench,	0	5
2. Clay,	1	2
1. Coal, lower bench,	3	9

UPPER FREEPORT COAL.

SAMPLE AND SECTION 142.

Sander's Mine, section 17, Walnut township, Gallia county. Lower bench only sampled, the upper bench not mined. Mine had not been worked for three years, but coal appeared fresh. The surface of the coal was cut off before sampling. Sampled by E. E. Somermeier in August, 1902.

SECTION 142

	Ft.	In.
4. Coal, upper bench,		
3. Shale, coal, and clay,	0	9½
2. Coal, lower bench,	2	10
1. Fire clay,		

Chemical analysis and calorific value of Sample 142:

Ultimate.		*Proximate.*	
Carbon	63.48	Moisture	7.62
Hydrogen	5.19	Volatile Comb.	32.85
Oxygen	15.85	Fixed carbon	47.14
Nitrogen	1.28	Ash	12.39
Sulphur	1.81		
Ash	12.39		

Calorific value .... 6,371 calories.

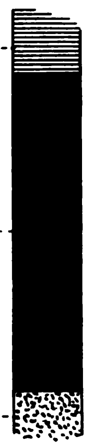
UPPER FREEPORT COAL.

SAMPLE AND SECTION 143.

Mine of William Sneed, section 26 or 27, Symmes township, Lawrence county. One bench only sampled, that being the only part mined. Fresh face of coal. Sampled by E. E. Somermeier in August, 1901.

SECTION 143

	Ft.	In.
3. Shale,		
2. Coal,	3	2
1. Clay,		



Chemical analysis and calorific value of Sample 143:

Ultimate.		*Proximate.*	
Carbon	64.90	Moisture	8.38
Hydrogen	5.18	Volatile Comb.	31.45
Oxygen	16.72	Fixed carbon	50.08
Nitrogen	1.27	Ash	10.09
Sulphur	1.84		
Ash	10.09		

Calorific value .... 6,497 calories.

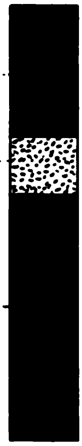
UPPER FREEPORT COAL.

SAMPLE AND SECTION 144.

Walter Rose Mine, section 21, Aid township, Lawrence county. Good sample of lower bench, the upper bench not mined. Sample cut by E. E. Somermeier in August, 1901.

SECTION 144

	Ft.	In.
3. Coal, upper bench,	1	4
2. Clay,	0	7
1. Coal, lower bench,	2	6



Chemical analysis and calorific value of Sample 144:

Ultimate.		*Proximate.*	
Carbon	63.03	Moisture	7.85
Hydrogen	5.09	Volatile Comb.	32.90
Oxygen	15.79	Fixed carbon	47.07
Nitrogen	1.25	Ash	12.18
Sulphur	2.66		
Ash	12.18		

Calorific value .... 6,305 calories.

UPPER FREEPORT COAL.

SAMPLE AND SECTION 145.

Haskin's Mine, section 36, Aid township, Lawrence county. Sample taken from lower bench only, the upper bench not mined. Sampled by E. E. Somermeier in August, 1901.

Chemical analysis and calorific value of Sample 145:

Ultimate.		*Proximate.*	
Carbon	66.94	Moisture	8.37
Hydrogen	5.21	Volatile Comb.	31.80
Oxygen	17.02	Fixed carbon	51.60
Nitrogen	1.31	Ash	8.23
Sulphur	1.29		
Ash	8.23		

Calorific value .... 6,596 calories.

SECTION 145

	Ft.	In.
4. Coal, upper bench, not mined,	1	0
3. Shales, very hard,	1	0
2. Coal, lower bench,	3	2
1. Fire clay,		

UPPER FREEPORT COAL.

SAMPLE AND SECTION 146.

Mine of Thomas Bennett, section 35, Aid township, Lawrence county. Both benches included in sample. Sampled by E. E. Somermeier in August, 1901.

SECTION 146

	Ft.	In.
5. Shale,		
4. Coal, upper bench,	1	0
3. Shale,	0	1½
2. Coal, lower bench,	3	0
1. Fire clay,		

Chemical analysis and calorific value of Sample 146:

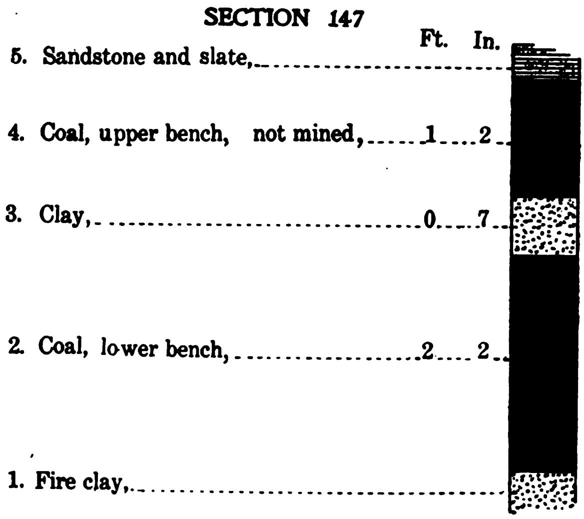
Ultimate.		*Proximate.*	
Carbon	65.20	Moisture	8.45
Hydrogen	5.10	Volatile Comb.	31 25
Oxygen	16.21	Fixed carbon	49.02
Nitrogen	1.28	Ash	11.28
Sulphur	0.93		
Ash	11.28		

Calorific value ....6,405 calories.

UPPER FREEPORT COAL.

SAMPLE AND SECTION 147.

Mine of Frank Kitts, section 16, Lawrence township, Lawrence county. Lower bench only sampled, the upper bench not worked. Sampled by E. E. Somermeier in August, 1901.



Chemical analysis and calorific value of Sample 147:

Ultimate.		*Proximate.*	
Carbon	65.03	Moisture	7.20
Hydrogen	5.03	Volatile Comb.	32.25
Oyxgen	15.69	Fixed carbon	49.88
Nitrogen	1.25	Ash	10.67
Sulphur	2.33		
Ash	10.67		

Calorific value ....6,556 calories.

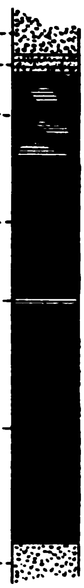
UPPER FREEPORT COAL.

SAMPLE AND SECTION 148.

Mine of Blue Rock Coal Company, Harrison township, Muskingum county. Good sample cut from a section 12 by 7 inches, by B. A. Eisenlohr in July, 1902.

SECTION 148

	Ft.	In.
7. Soapstone,		
6. Sandstone,		
5. Cannel coal, shaly,	9 to 11	0
4. Coal, upper bench,	1	5
3. Parting,	0	1
2. Coal, lower bench,	2	4
1. Fire clay,		



Chemical analysis and calorific value of Sample 148:

Ultimate.		*Proximate.*	
Carbon	67.74	Moisture	4.89
Hydrogen	5.53	Volatile Comb.	42.35
Oxygen	13.42	Fixed carbon	44.98
Nitrogen	1.17	Ash	7.78
Sulphur	4.36		
Ash	7.78		

Calorific value ....6,944 calories.

UPPER FREEPORT COAL.

SAMPLE AND SECTION 149.

Mine of Maynard Bros., Brush Creek township, Muskingum county. Sample fair. Cut from section 12 by 4 inches, by B. A. Eisenlohr in August, 1902.

SECTION 149

	Ft.	In.
5. Shale,		
4. Coal, upper bench,	1	4
3. Pyrites,	0	1½
2. Coal, lower bench,	2	7
1. Fire clay,		

Chemical analysis and calorific value of Sample 149:

Ultimate.		*Proximate.*	
Carbon	68.27	Moisture	4.72
Hydrogen	5.55	Volatile Comb.	43.47
Oxygen	12.30	Fixed carbon	44.25
Nitrogen	1.32	Ash	7.56
Sulphur	5.00		
Ash	7.56		

Calorific value ....7,046 calories.

UPPER FREEPORT COAL.

SAMPLE AND SECTION 150.

Zanesville Coal Company's Mine, Wayne township, Muskingum county. Sample fair. Cut from a section about 12 by 4 inches, by B. A. Eisenlohr in August, 1902.

Chemical analysis and calorific value of Sample 150:

Ultimate.		*Proximate.*	
Carbon	64.81	Moisture	5.11
Hydrogen	5.11	Volatile Comb.	35.50
Oxygen	12.39	Fixed carbon	46.79
Nitrogen	1.25	Ash	12.60
Sulphur	3.84		
Ash	12.60		

Calorific value ....6,558 calories.

SECTION 150

	Ft.	In.
7. Sandstone,		
6. Soapstone,	4	0
5. Coal, upper bench,	1	8
4. Parting,	0	1
3. Coal, hard and flinty,	1	10
2. Coal, lower bench,	2	2
1. Fire clay,		

UPPER FREEPORT COAL.

SAMPLE AND SECTION 151.

Mine of Wm. Darr, section 22, Clark township, Coshocton county. The upper bench only is mined, and the sample was cut from this. The sample measured about 22 by 4 inches and was cut by B. A. Eisenlohr in August, 1902.

SECTION 151

	Ft.	In.
6. Soapstone,		
5. Impure coal,	0	5
4. Coal, upper bench,	2	4
3. Parting,	0	2
2. Coal, lower bench,	0	6
1. Fire clay,		

Chemical analysis and calorific value of Sample 151:

Ultimate.		*Proximate.*	
Carbon	72.72	Moisture	6.40
Hydrogen	5.67	Volatile Comb.	37.92
Oxygen	15.16	Fixed carbon	52.49
Nitrogen	1.25	Ash	3.19
Sulphur	2.01		
Ash	3.19		

Calorific value ....7,325 calories.

CHAPTER VIII.

INTERPRETATION OF THE CHEMICAL AND PHYSICAL TESTS OF COAL.

BY PROFESSOR N. W. LORD, OHIO STATE UNIVERSITY.

The investigation of the coals of Ohio, the results of which are published in this volume, contemplated among other things a complete series of the proximate and ultimate analyses of samples representing the various seams together with the determination of their calorific values and in some cases experiments on their coking properties. As the purification of coal by washing is of growing importance, some experiments were also made on the separation of the coals along the lines of specific gravity, to obtain data of service in determining the adaptability of certain seams to this method of improvement. Complete records were kept of the location, geological position and character of the seam where the samples were taken, and are discussed in the foregoing chapters of the report.

The laboratory work was all done in the Department of Metallurgy and Mineralogy of the Ohio State University by Professor Somermeier and his assistants. The methods used are fully discussed in Professor Somermeier's chapter upon this subject. The present chapter will deal with the meaning of the results obtained and their use in giving information both to the seller and user of the coals covered by the investigation.

In order to properly discuss this part of the work, it will be necessary to briefly review the general nature and character of coal considered as a fuel. It is a matter of common knowledge that coal is the product produced by the alteration and concentration of woody fiber and other products of vegetation when buried out of contact with air. The nature of the organic matter as affected by the kind of vegetation is probably of importance as affecting the properties of the coal, as is also the extent of the alteration to which it has been subjected since its deposition.

In considering a particular coal seam there are several items which are closely related to the geological conditions existing during its formation, such as the nature of the soil on which the coal forests grew, the drainage, water currents, etc., and the extent of the disturbance of the strata occurring subsequently to the covering of the deposits. These matters are primarily subjects for discussion by the geologist. They influence the occurrence of partings and seams, the percentage and kind of ash in the fuel, and may be local or general in their effects.

From the standpoint of their character and value as fuels coals may be considered as composed of three main constitutents:

(1) Water, or "moisture," as it is designated in the analysis.
(2) The "combustible organic matter" of the coal representing the products of the vegetation purely.
(3) The mineral impurities which produce the ash and are accountable for more or less of the sulphur, phosphorus, and other deleterious substances affecting the use of the coal.

Different seams of coal show marked variation in the relative proportions of these constituents, and in the way in which the mineral impurities are intermixed or distributed in the seam. In regard to the second and third items, the nature of the material itself is subject to differences in the different seams or in the same seam in different localities.

(1) The water or moisture in a coal may be considered as of two kinds: First, water present mechanically but in no sense in combination with the fuel, such water as would be retained in the coal if it had been rained upon or in any other way exposed to addition of water. This mechanically held water is frequently present in samples of coal taken for commercial purposes and is always present in samples of coal taken from coal washers. The amount of water that may be mechanically held by coal is greatly influenced by the fineness of the material, lump coal retaining in this mechanical way but a small percentage of water.

A sample of domestic egg coal ranging in size from 1¼ inch to 3¼ inch after being taken from a washer and allowed to drain for twenty-four hours in the bins showed an air-drying loss of 2½ per cent. A carload of the slack of the same coal, ⅝-inch and under, after the same treatment showed an air-drying loss of 10.2%. This shows that the fine slack coal retained about four times as much water as the larger screened coal. As some of the loss on air-drying was possibly due to water in other conditions, it is probable that the difference in the amount of water retained mechanically was even greater than shown by the foregoing results. In the coal samples taken from the mine probably but little of the water is in this purely mechanical condition unless the sample has been wet or taken from a wet face.

The second condition in which the water occurs in the coal is that in which it is retained with some degree of affinity, but is expelled easily by drying either in the air at ordinary temperatures or at a temperature but little exceeding the boiling point of water. It is impossible to draw a sharp line between the water in coal held mechanically and this latter form of moisture. The two run into each other to a certain extent. Coal freshly mined usually contains considerable water which will dry out of it rapidly if the coal is broken up to one-half inch size and then exposed to the air at ordinary temperatures.

Extended experiments have shown that a sample of crushed coal exposed to the air will, after a time, reach a condition in which an increase in the moisture present in the air will cause the coal to re-absorb moisture and show a larger percentage of water while a reduction of the percentage of moisture in the air will be followed by a corresponding drop in the percentage of moisture retained by the coal. Coal that has reached such a condition of equilibrium for one degree of fineness may take another condition of equilibrium if it is reduced to a finer powder.

If coal is finely powdered, and then heated to 105°C. in dry air, the free water present as such may be considered as all expelled. This does not mean that the coal on higher heating will not give off more water but that when the coal is heated to this temperature, it reaches a condition of equilibrium which is practically constant for the same coal. The water expelled from the coal at this temperature is what is reported and considered in an analysis as the moisture in the coal. Water retained by the coal under these conditions is in a sufficiently close combination with the coal to be entitled to be considered as an integral part of the coal and cannot be expelled without decomposition of some of the other ingredients. Coal which has been pulverized and dried at this temperature is designated as "dry coal" and so considered in the discussion of the fuels.

In many of the samples tested in the work determinations have been made of the loss on "air drying." This loss corresponds roughly to the water loosely retained in the coal and which would be dried out of it when the coal stands exposed to the atmosphere for some time. The figure is by no means to be taken as having any close meaning as its value will depend considerably on the dryness of the air and the fineness of the coal. The moisture reported in the analysis is the moisture present in the sample of coal as received in the laboratory and is probably less than the percentage of moisture in the coal as it would be if freshly mined, except in those samples where the air drying loss was determined and the analysis corrected to the sample as taken.

(2) The combustible organic matter in the coal. When a sample of coal is burned completely there is left the inorganic ash and the sum of this ash and the moisture present in the coal is frequently considered as the non-combustible portion of the fuel, and the difference between the sum of these amounts and the total amount of coal assumed to be the combustible or fuel portion of the coal.

A little consideration will show that this method of calculation is not correct. The ash stands, not for the mineral matter as it exists in the coal, but for what remains after that mineral matter has been exposed to the effect of oxygen and a high temperature. For example if the coal should contain iron carbonate, the iron would be left in the ash as sesquioxide, involving a considerable loss in weight due to the expulsion of the carbon dioxide. Iron pyrites, usually present in coal, appears in the

ash as iron oxide, the sulphur being largely expelled as sulphur dioxide with a loss in weight of the mineral residue from the expulsion of sulphur which is partially compensated for by the weight of the oxygen absorbed in the change. In this way eight parts of pyrites in the coal will appear as five parts of oxide of iron in the ash. Coals usually contain slate and clay. These hold water which is only expelled at a red heat. This is a source of error if the ash is taken as equivalent to the mineral matter. It is obvious, therefore, that the method of determining the combustible or organic portion of the coal by subtracting the ash plus the moisture from the total weight of the coal is defective and liable to be misleading, the results being only an approximation to the truth, the error increasing with the weight of ash and sulphur present.

A more accurate determination of the total amount of the combustible matter in the coal may usually be obtained from the ultimate analysis, in which the actual amounts of carbon, hydrogen, nitrogen and sulphur present are determined. In the absence of carbonates, which are rarely found in more than very small amounts in coals, the carbon in the coal may be taken as practically wholly derived from organic and combustible sources.

The hydrogen in the coal can be divided into two parts, that present in combination with carbon and that which forms water with the oxygen present in the coal. The generally close agreement between the calorific values calculated by Dulong's formula and those determined directly in the calorimeter would indicate that the oxygen in the coal is largely in such combination as to be equivalent to water as far as heat development is concerned. In considering the composition of coal dried at 105° an amount of the hydrogen equal to $\frac{1}{8}$ of the oxygen present may be assumed as forming with this oxygen the water combined with the organic and mineral matter in the fuel and which will be liberated as water when the fuel is burned. A portion of the sulphur and practically all of the nitrogen may be considered as included in the organic constituents of the coal.

The percentage of oxygen in the analysis is determined by difference, that is, by subtracting the sum of the carbon, hydrogen, nitrogen, sulphur and ash from 100. The result so obtained is in error, being too small by the oxygen absorbed in the ash. If all the sulphur is present as iron pyrites the error would be equal to $\frac{3}{8}$ of the sulphur in the coal, but as only a portion of the sulphur is so present the application of this correction cannot be made when only the total sulphur is known.

Probably the closest approximation to the "organic matter" in the coal is given by the sum of the carbon, hydrogen, oxygen and nitrogen present in the dry fuel. Some sulphur would be included in the organic matter, but this would be in part balanced by any water in the mineral matter expelled in burning to ash, thus causing the oxygen to be estimated too high.

(3rd) Mineral Impurities. The ash in the coal left on burning, as explained above, is not equal in amount to the mineral matter in the coal for the reason that many of the mineral substances present in the coal are altered in the process of combustion.

Coal ash contains silica, alumina, oxides of iron with frequently small amounts of potash, lime and magnesia, the amount of potash sometimes amounting to as much as 2½ or 3%. The source of oxide of iron in the ash is in part at least the combustion of the pyrites, the oxide so derived frequently gives a reddish color to the ash. The silica and alumina are largely derived from clay and sand intimately mixed with the coal in the process of formation or scattered through it as partings or seams of slate. As clay always contains a considerable percentage of water, which is not expelled except at a comparatively high temperature, it is obvious as before stated that in a coal containing considerable ash, especially if high in alumina, there is liable to be noticeable percentage of oxygen and hydrogen present in the ultimate analysis of the dry coal derived from this source and not from the organic matter in the fuel.

A matter of more practical moment in considering the ash in any sample of coal is the distribution of the ash in the seam. Some coals contain considerable percentages of slate, which brings up the ash to a rather high figure, if the sample represents the average of the seam, but if the coal is carefully selected, so as to include none of these slate formations, a low figure for ash would be obtained in the analysis. In coals of this character the screened lumps would show a much lower ash content than the run of mine. In other cases the ash is disseminated through the whole coal and is practically uniform in various parts of the seam and cannot be separated from the coal. Bone coals are of this character, showing a high ash content throughout. This distinction in the distribution of the ash is of prime importance in considering the adaptability of the coals to improvement by washing, as will be discussed later in this chapter.

One of the most important of the impurities of coal is sulphur. The percentage of sulphur in coal is frequently very large. It occurs in coal in at least three ways: The most prominent is in iron pyrites. This mineral is easily recognized in many samples and sometimes forms large masses scattered through portions of the seam, in other samples it occurs as thin plates, in others as very fine grains scattered through the coal in particles too small to be separately recognized. In some of the coals in Ohio, the principal source of sulphur is due to the presence of iron pyrites. A second source of sulphur is the presence of sulphates of iron alumina or lime. It is probable that little or none of these exist in coals that have not had access to recent atmospheric influence, as on exposure to air, some forms of pyrites rapidly absorb oxygen, becoming converted to sulphates, while on the other hand sulphates out of contact with air

are reduced back to sulphides by organic matter. In coals that have been long exposed either in the laboratory or to the weather considerable percentages of such sulphates are frequently found. An important form of sulphur in coal is what is usually designated as "organic sulphur" or sulphur in forms of combination other than the foregoing. But little is known of the actual substances in which the sulphur combines, some coals showing considerable percentages of sulphur even where little pyrites can be recognized or the presence of any appreciable amount of sulphates detected. A little of the sulphur not accounted for as sulphides or sulphates is found as free sulphur in some samples but it mostly appears to be in organic combinations.

The carbon, hydrogen, nitrogen, and oxygen in the ultimate analysis stand for definite substances in the coal. They are reported on the sample as received in the laboratory and include the hydrogen and oxygen present in the moisture in the fuel. In addition to the ultimate analysis the "volatile combustible matter" and the "fixed carbon" are given and the determination of the moisture expelled on heating to 105°.

As has been previously explained, the moisture merely represents that which is expelled from the coal when dried under given conditions and by no means represents all the water which would be given off when the coal is completely burned. The volatile combustible matter and the fixed carbon represent what is usually called the "proximate analysis" of the coal, the "fixed carbon" is the combustible material left in the coke or residue after the coal has been heated to a high temperature in a prescribed manner and for a definite time, and approximately represents what combustible would be left in the coke when the coal is coked. It does not represent all the carbon in the coal, as is clearly seen in comparing the figures for the "fixed carbon" with those given for carbon in the ultimate analysis of the same fuel. The volatile combustible matter represents the volatile material driven off by a high temperature out of contact with air and includes the water formed in the decomposition of the coal by heat, but not that present in the coal as "moisture" at 105°C.

The relation of the fixed carbon to the total carbon varies in different seams and very considerably in different samples from the same seam, though there is a general correspondence in this ratio in coals of the same seam. It should be clearly understood that the fixed carbon is not a definite ingredient of the coal but merely the result obtained by a special method of treatment of the coal, differing in this way radically from the carbon of the ultimate analysis.

A matter of considerable interest is the relation of the sulphur in the coal to the sulphur obtained in the coke. This relation varies greatly in different coals and no general rule can be made for it. A number of determinations will be given later of the percentage of the total sulphur retained by the coke in several samples of Pittsburg coal.

THE HEATING VALUE OF COAL.

The calorific value of a coal is the total amount of heat developed by its complete combustion. It is expressed in the tables in calories, the calorie being the amount of heat required to raise the temperature of one kilogram of water one degree Centigrade. The heating value of coal is frequently expressed in British thermal units, a British thermal unit being the quantity of heat required to raise the temperature of one pound of water one degree Fahrenheit. Calorific values given in calories can be converted into calorific values expressed in British thermal units by multiplying the value in calories by 1.8.

The heat of combustion of coal is due to the oxidation of the carbon, the hydrogen not combined with oxygen, the sulphur and the iron not already in combination with oxygen, but the amount of heat produced by the combustion of these elements in combination is not always exactly the same as would be produced by the combustion of the free elements separately. The difference is not so great but that the heat can be calculated from the amounts of the elements present with a fair degree of accuracy.

This is done by what is known as Dulong's formula: $8080C+34460(H-\frac{1}{8}O)+2250\ S$, in which C, H, O and S stand for the amounts of carbon, hydrogen, oxygen and sulphur respectively in the coal. On comparing the average of the different seams it will be seen that the values by Dulong's formula range from 32 calories to 106 calories below those determined by the calormeter. It is not probable that this variation is altogether due to the uncertainty of the determinations, especially the oxygen, but corresponds to actual differences in the heat developed by the different elements when burned in the combinations in which they exist in the coal. Individual variations greater than those indicated in the average occasionally occur while in several samples the results obtained by the direct measurement correspond almost exactly to those calculated by Dulong's formula, and in some cases the results from Dulong's formula are higher than those obtained by direct measurement, though the general tendency is for them to be lower. With very few exceptions the results obtained by Dulong's formula lie within 1½% of the correct calorific value, so that within this limit the formula is useful.

If it be assumed that the calorific value of the coal is due to the combustion of the organic matter and the sulphur, it would seem probable that in coals of like character the calorific value would be proportional to the amount of these substances present. If the percentage of the ash, the moisture and the sulphur be subtracted from 100, the remainder would be approximately the organic matter in the coal and if the calorific value of the sulphur be subtracted from the calorific value of the coal as determined, the remainder should be the calorific value of the organic

matter present. Calculating this to unity gives the value designated as "H" in the table.

In other words, "H"=calorific value minus 2250 times the sulphur, and divided by 1 minus the sum of the ash ,the moisture and the sulphur, the ash, moisture and sulphur being that present in the unit weight of coal. This value for "H" is given for the average of each of the coal seams tested. By reversing this process, the calorific value of each sample has been re-calculated from its ash, moisture and sulphur content by multiplying the value of "H" by one minus the sum of the sulphur, ash and moisture and adding the sulphur multiplied by 2250.

It will be seen by comparison of results that in the great majority of cases the calculated values correspond within 1½% of the determined values. Occasionally very considerable variations occur. This would indicate that the assumption that the value of "H" or the calorific value of the organic matter was the same for the whole of an extensive seam was not wholly justified. However, an investigation of the largest variation which occurs in the No. 6 coal in sample 112, where the value calculated from "H" exceeds the value determined in the calorimeter by 8.8%, shows that the sample was taken from the entry about 200 feet from the mouth in a mine, where it had probably been exposed for a long time to the weather. This with its very large percentage of water would seem to indicate that the sample had suffered much alteration from its original condition in the seam.

By comparing the results obtained from "H" in smaller groups of samples covering a limited locality and where the samples were obtained from fresh coal, the agreement between the calculated and determined values is usually close, indicating that in limited portions of a seam and from neighboring mines, the calorific values obtained in the table may be applied with close approximation to the truth to calculate by this method the calorific values of other samples of which the ash, moisture and sulphur are known. This is particularly true for samples representing various shipments of coal from a single mine where the calorific value will vary very closely with the organic matter and sulphur used according to the formula. On the other hand, weathering of the coal by changing the condition of the sulphur and increasing the amount of water in combination with sulphates will rapidly reduce the actual value of the coal as compared with what it should be by the formula, which should never be applied to anything but fresh samples of coal taken from unaltered portions of the seam.

THE AVAILABLE HEAT OF COAL.

The calorific value of coal represents the total heat developed by its combustion. Only a portion of this value can be actually utilized in any practical application of the fuel. A certain amount of it is necessarily

wasted in heating the products of combustion of the fuel and in other ways incident to imperfections of furnaces, etc. The amount of useful heat which a given coal can furnish under given conditions can be approximately estimated from its ultimate analysis and its calorific value.

This may be called the "Available Calorific Power" of the coal and would represent the remainder after subtracting the heat necessarily wasted in the operation. This wasted heat is made up of three main items: (1st) The heat required to raise the products of combustion including the nitrogen in the air necessary to burn the fuel to the temperature at which they escape through the chimney. (2nd) The heat required to evaporate and carry off the moisture in the coal as well as the water formed by the combustion of the hydrogen in the coal; and lastly, the heat required to raise to the temperature of the chimney the air passing through the furnace in excess of that actually required to burn the fuel. Of course, in actual experience other losses than these will be encountered, losses due to the incomplete combustion of the volatile portions, losses due to radiation, losses due to unburned coal escaping through grates, losses due to heat absorbed by the moisture in the air, etc., but these losses are to a certain extent mechanical and depend on the care used in firing.

The first set of losses are, however, connected intimately with the composition and character of the fuel and cannot be reduced below a certain amount. Different coals will differ in the percentage of their calorific value that is available. The percentage available diminishes with the amount of water and oxygen in the coal and increases with the amount of carbon. If it be assumed that an air excess of 50 per cent. is necessary for the complete combustion of the coal under ordinary conditions, the theoretical available calorific value of a coal could be determined by the following calculations in which H. O. C. S; N, and ash represent the respective amounts of these elements present in the coal; small t and large T the temperature of the air (and fuel) before combustion and the temperature of the escaping flue gases respectively.

The "Available Calorific Power" equals the total calorific value diminished by first, the latent heat, second, the product of the excess temperature of the products escaping and the water equivalent of the products of combustion including the nitrogen in the air consumed; and, third, the product of the excess temperature of the products escaping into the water equivalent of the excess air present.

The value of these deductions is obtained as follows:

First, The latent heat. This equals nine times the hydrogen multiplied by $(536.5+.52\ (100-t)$. The item $.52\ (100-t)$ being the correction for the difference between the specific heat of water and the specific heat of water vapor.

Second, The products of complete combustion are carbon dioxide, water vapor, sulphur dioxide, nitrogen and ash. The amounts of these

obtained from the unite weight of coal will be $\frac{11}{3}$ of the carbon for the carbon dioxide; nine times the hydrogen for the water vapor; two times the sulphur for the sulphur dioxide and the ash and nitrogen as shown by the analysis. The water equivalent of the products of combustion is obtained by multiplying each of these items by its specific heat and adding the products.

The nitrogen in the air used for combustion is equal to nearly 3.33 times the oxygen required from air for combustion. This oxygen is equal to $\frac{8}{3}$ of the carbon plus eight times the hydrogen plus the sulphur, minus the oxygen contained in the coal. The nitrogen thus calculated multiplied by the specific heat of nitrogen gives the water equivalent of the nitrogen from the air. Similarly, the amount of ash multiplied by its specific heat gives the water equivalent of this item: The sum of all the water equivalents obtained as above multiplied by the difference between the temperatures at which the products escape and the temperature of the air supplied for combustion gives the heat carried off in the products of combustion according to the second item in the general expression

Third. The excess air present is equal to the amount of air required for combustion multiplied by the ratio of the excess air to that required. The air required for combustion is 4.33 times the oxygen required for combustion or 4.33 times the sum of $\frac{8}{3}$ of the carbon plus eight times the hydrogen plus the sulphur minus the oxygen in the coal. The ratio of the excess air present to that used for combustion can be obtained from the analysis of the gases passing out of the chimney. If the small amount of nitrogen present in a coal be neglected the ratio of the air present in the chimney gases to the air used in combustion is equal to $\dfrac{\text{oxygen}}{\frac{3}{10}\text{ of the nitrogen—oxygen}}$, in which the oxygen and nitrogen are percentages by weight of the gases. Where the percentages are given by volume the formula becomes

$$\frac{\text{the oxygen}}{\frac{20.8}{79.2}\text{ nitrogen—the oxygen}}$$

If the fuel contains nitrogen in considerable quantity, which is the case with gaseous fuels, the formula will have to be modified. If V^1 be the volume of gaseous carbon in 100 volumes of flue gas and V the volume of gaseous carbon in 100 volumes of the fuel, considered as a gas, the percentage volume of the nitrogen from the fuel in the flue gas will equal $\frac{V^1 E}{V}$ where E is the percentage by volume of nitrogen in the fuel and the formula for the ratio of air excess will be

$$\frac{O}{\frac{20.8}{79.2}\left(N - \frac{V^1 E}{V}\right) - O}$$

The volume of gaseous carbon is, of course, equal to $\frac{1}{2}$ CO_2 plus $\frac{1}{2}$ CO plus $\frac{1}{2}$ CH_4 in the gas, or génerally, the volume percentage of any gas, divided by twice the number of carbon atoms it contains.

The exactness of the above formula for the available heat depends upon the values for the specific heats. The specific heat of nitrogen is usually taken at 0.24 and probably does not change materially at very high temperatures. The specific heat of air is usually taken at 0.237 and probably does not vary to important amounts as the temperature increases. The specific heat of carbon dioxide for ranges of temperature between zero and 350 C is usually taken at .22, but as the temperature increases above this range it rapidly increases and for ranges up to 1,000 degrees will average between .29 and .3 according to the figures quoted by Ackerman. The mean specific heat of water vapor from temperatures of one degree up to 350 degrees will average about .48, increasing as the range increases and by the same authority at 1000 degrees it becomes practically .68. The specific heats of sulphur dioxide and ash up to ranges of 350 are about .15 for the former and .16 for the latter. The foregoing values enable the formula for the available heat to be applied to ordinary conditions of boiler practice with a considerable degree of accuracy.

As an illustration, the available calorific value of the No. 6 coal as based on the average analysis of the seam and under conditions corresponding to the use of the coal in a steam boiler of the best type working under the best conditions is calculated as follows: The excess of air under the conditions assumed is taken at 50%, flue temperature at 300° and the temperature of the air at zero, the temperature at which the ash is withdrawn from the furnace the same as the temperature of the air. The composition and the calorific value are:

Carbon	.6903
Hydrogen	.0543
Nitrogen	.0126
Oxygen	.1362
Sulphur	.0330
Ash	.0706
Calorific value	6,980 calories.

The latent heat equals $9 \times .0543 \times (536.5 + .52\ (100) = 287.5$.

The water equivalent of the products of combustion exclusive of the nitrogen in the air equals:

$$\begin{array}{lr} .6903 \times \frac{11}{3} \times .22 = & 0.5568 \\ .0543 \times 9 \quad \times .48 = & 0.2345 \\ .0330 \times 2 \quad \times .15 = & 0.0990 \\ .0126 \times 0.24 \qquad = & 0.0032 \\ \hline & 0.8935 \end{array}$$

The oxygen in the air used in combustion equals:

$\frac{8}{3}$ x .6903	= 1.8408
8 x .0543	= .4344
Sulphur	= .0330
	2.3082
Deducting the oxygen in the fuel	.1362
	2.1720

The water equivalent of the nitrogen in the air corresponding to the oxygen equals $3.33 \times .24 \times 2.1720 = 1.7359$.

The water equivalent of the products of combustion plus the nitrogen from the air equals the sum of these two water equivalents, which is 2.6294 which multiplied by 300°, the flue temperature. equals 788.8. the sensible heat carried off in the products of combustion.

The excess air equals the oxygen (2.1720) multiplied by 4.33 and by .5, (the ratio of air excess) giving 4.7024. The heat carried off in excess air equals:

$4.7024 \times .237 \times 300° = 334.3$ heat units.

Writing these various values together and adding them, we have as follows:

287.5 Latent heat.
788.8 Heat lost in products of combustion including N. from air used.
334.3 Heat lost in excess air in flue gas.

1,410.6 Total.

Deducting the sum—1410.6—from the calorific value of the fuel—6980—leaves 5569.4, as the heat theoretically available per unit of fuel and under the conditions assumed. This is equal to about 80% of the total calorific value.

The evaporating power of a coal as used in boilers is more or less closely connected with the available heating power, but, of course, is greatly modified by the adaptability of the coal to burning on the particular grate and in the particular furnace used. Certain other losses occur under the best construction and can only be partially avoided even in the best practice. If the sum of these other losses be deducted from the available heating power, the practical evaporating power per pound of coal in pounds of water at the boiling point turned into steam at the same temperature, would be the remainder divided by 536½. Coals differ in the percentage of the excess of air required for their complete combustion and it is well known that experience with the kind of coal is necessary to use it to the best advantage.

A large number of experiments on the boilers of the United States Government Fuel Testing Plant at St. Louis have shown an average loss

of approximately 10 per cent. of the calorific value of the coal in undetermined losses connected with radiation, incomplete combustion, etc. If it be assumed that this figure represents first class practice, the evaporating power which should be obtained from a coal under the best conditions in use would be approximately the available calorific power as estimated before, less 10% of the calorific value and divided by 536.5. As an example, if 10% of the calorific value be deducted from the available calorific power of the above coal there is left 5568.7—698.=4870.7 and this divided by 536.7=9.07 as the number of pounds of water 1 lb. of this coal should evaporate under the best boiler conditions.

As it is rarely possible to completely burn the coal, five per cent. may be assumed for loss through the grates, in smoke and other modes of incomplete combustion, which would reduce the figure to 9.07—.45=8.62 as the best practical evaporative power of the average of the No. 6 coal in boilers not provided with special means of saving the chimney losses.

Larger air excess or higher flue temperature will of course increase the losses proportionately.

Thus 100% excess of air, a figure more usually found, would double the loss due to this cause and reduce the available heat by a further 334.5 units or reduce the evaporation by 334.5 divided by 536.5=.62 or to 8.00 lbs. from and at the boiling point.

It is not to be understood that these figures are generally realized with the coal but represent the actual possibilities of the coal which is certainly capable of giving these results.

The relative commercial value of coals as indicated by their analysis and calorific value may be considered under two aspects: In the first place, as to the actual heating value of the combustible portion of the coal and the percentage of this heating value available. In a general way the calorific values of fuels are an indication of their relative fuel value, but from what has preceded it is evident that a closer comparison of the relative values of coals for any particular purpose will be afforded by a comparison of their available calorific power under the conditions as to temperature and combustion under which they are to be used.

Coals which contain or furnish on burning large percentages of water will give low percentages of available heat calculated on their total calorific power both from the latent heat and the large quantity of heat carried off in the water vapor in the products of combustion. The effect of this latter item will be increasingly seen, as the temperature at which the gases escape is increased. An important result is also to diminish the possible furnace temperature obtainable where coals producing large quantities of water vapor are used. Inspection of the analytical tables given later on in this report shows that the Ohio coals differ but little in different seams in their hydrogen and oxygen percentages, so that this cause of difference is not particularly important in com-

paring the coals of this state, but becomes important if they are to be compared with other fuels differing widely in moisture and oxygen percentages. It is obvious that the moisture determination is one of importance and always to be considered in connection with the total calorific value of the coal.

In the second place the effect of the impurities, moisture, ash and sulphur, on the value must be considered. These affect the available heat produced by the coal. The ash by replacing the combustible matter acts directly in reducing the total calorific power of the coal and of course proportionately the available calorific power of the coal. A coal with 15% of ash will have 5% less combustible matter than one with 10% of ash, so that from this point of view alone the relative values of the two coals would be approximately as 85 to 90. The sulphur in a coal has a heating value of its own and when in the form of pyrites produces probably in the neighborhood of one half as much heat by its combustion and that of the iron combined with it, as would the organic matter that it replaces.

The moisture in the coal as has already been indicated, not only reduces the heating value by the organic matter it replaces but diminishes by a considerable amount the availability of the heat produced by combustion. Five per cent. of water under the conditions of ordinary boiler practice would not only reduce the heating power by five per cent., but would increase the latent heat by about thirty calories. The excess of loss produced by moisture will partly offset the heat produced by the combustion of the sulphur, so that the relative values of the coals having the same value for the combustible would be approximately proportionate to one minus the ash, the moisture and the sulphur. In other words, coal in a given seam with five per cent. of moisture, ten per cent. ash and two per cent. of sulphur as compared with a coal with eight per cent. of moisture, twelve per cent. of ash and four per cent. of sulphur would rank as about 1—17 to 1—24 or as 83 to 76, or on a percentage basis, one ton of the purer coal would be equivalent to nearly 1.1 of the more impure.

Many other considerations, however, besides the actual heating value enter into the relative value of coal. Excess of ash of course involves extra expense in handling. Excess of sulphur for many purposes is injurious to the process to which the coal is applied. No general rule can be given for these items, as they depend upon the application of the coal and other special conditions.

The tendency of coal to smoke and form soot varies greatly but the loss of heat due to the formation of soot is very small and the effect on the value of coal for heating purposes but slight, though for many other reasons it may be a large factor in determining the relative values of coal for special purposes. The character of the ash distinct from its amount is a factor not represented in the analysis, but of importance, badly

clinkering or fusing ash being highly objectionable in coals used for certain purposes.

ANALYTICAL RESULTS.

The tables which follow in this chapter give the analytical results and calorimetric determinations on the samples tested. The samples are grouped according to the geological classification of the coal seam. The samples in each group are arranged approximately according to their geographical location proceeding from the southern to the northern portion of the state.

The table headed "Moisture" gives the moisture in the coal as present in the sample as received in the laboratory. All the other determinations are upon the coal containing this moisture and not upon the dried sample. The oxygen as given in the tables is determined by difference.

The Clarion or No. 4 Coal.

The samples of this coal cover a territory forming a narrow strip running a little east of north from the junction of Scioto and Lawrence Counties to the middle of the eastern part of Vinton County. The coal in all cases is high in sulphur, in some samples running over six per cent. Inspection of the location of the samples shows a general tendency for the sulphur to run highest in the more easterly samples from the general direction of the line: However, there is apparently no definite law for the distribution of the sulphur or the ash, considerable variations occurring in samples from the same township. From the average analysis of all the samples the composition of the dry organic matter can be calculated on the assumption that it is equal to the sum of the carbon, hydrogen, nitrogen and oxygen in the dry coal, as follows: From the sum of the carbon, hydrogen, nitrogen and oxygen in the moist coal as given deduct the moisture. Divide the carbon, the hydrogen minus $\frac{1}{9}$ the moisture, the nitrogen and the oxygen minus $\frac{8}{9}$ the moisture by the remainder, and the quotients each multipled by 100 will give the percentage of carbon, hydrogen, nitrogen and oxygen in the dry organic matter in the coal.

In order to test the variations in different samples the average of the two highest sulphur coals in the No. 4 seam and the average of the two lowest sulphur coals were also calculated. The results were as follows:

Composition of the Dry Organic Matter of No. 4 Coal.

	Average of whole seam.	Average of Nos. 62 and 63, two highest sulphurs.	Average of Nos. 54 and 70, two lowest sulphurs.
Carbon	81.73	82.90	81.90
Hydrogen	5.93	5.87	5.92
Nitrogen	1.57	1.73	1.54
Oxygen	10.77	9.50	10.64
	100.00	100.00	100.00
Sulphur	4.33	6.11	3.09

It will be seen that there is considerable variation in the oxygen and in the carbon in the two sets of results as calculated. A further calculation was made to compare them in the same way after correcting the oxygen by adding an amount equal to ⅜ of the sulphur and then reducing to the percentage basis by dividing each of the items of the analysis of the dry organic matter by their sum with the oxygen so increased. The results are given for the three averages as follows:

Composition of the Dry Organic Matter in No. 4 Coal after correction for sulphur.

	Average whole seam.	Two highest sulphurs.	Two lowest sulphurs.
Carbon	80.05	80.44	80.80
Hydrogen	5.81	5.64	5.84
Nitrogen	1.54	1.72	1.50
Oxygen	12.60	12.20	11.86
	100.00	100.00	100.00

It will be seen that in this case the results are more nearly alike, from which it is a fair inference that the sulphur in the No. 4 coal is largely present as pyrites and that the ultimate analysis on this latter supposition is a nearer approximation to the composition of the dry organic matter than that obtained by the first method. If the composition of the organic matter of the seam be taken as that given by the results on the average of the seam, the ultimate analysis of any particular sample of the No. 4 coal could be obtained with a fair degree of accuracy from

the determination of the ash, moisture and sulphur for the particular sample.

The method of calculation would be to simply reverse that by which the foregoing results were obtained. In other words, subtract from unity the ash, the moisture and $\frac{5}{8}$ of the sulphur present in a unit weight of coal and multiply the items in the analysis of the organic matter corrected for sulphur by the result. This will give the carbon, hydrogen, nitrogen and oxygen for the particular sample, the oxygen being corrected for sulphur. By subtracting $\frac{3}{8}$ of the sulphur from the oxygen the result will be the oxygen as given in the ordinary analysis, where it is determined by difference. To include the hydrogen and oxygen present in the moisture in the coal, add $\frac{1}{9}$ of the moisture to the hydrogen and $\frac{8}{9}$ to the oxygen. The sum of the results plus the ash and the sulphur should equal 100%, as a check on the calculation. Of course, this method would not be satisfactory if applied to altered or weathered samples of coal, which have changed radically from the composition of the seam in its normal condition.

The average heating value of the No. 4 coal is 6637 calories, equivalent to 11947 B. T. U. The heating value of "H," as explained previously for the seam is 8223 caloris. The heating values for the different samples tested calculated from this average value for "H" are given in the table. In the majority of cases, the correspondence is fairly satisfactory, showing in a general way that the heating value of the coal after making due allowance for the variations in ash and moisture is approximately constant. It will be noted that the heating value in any sample by Dulong's formula does not differ by more than one per cent. from that determined by the calorimeter. It will be noted that there are wide variations in the percentage of ash, moisture and sulphur in the different samples of coal, indicating considerable difference in the cleanness of the coal from different points and the necessity of careful determination of these constituents in comparing the value of coals from different shipments.

The Lower Kittanning or No. 5 Coal.

The samples of No. 5 coal were taken at widely separated points over the state extending from the Ohio River on the south to Mahoning County on the north. Considerable variations in the quality of the coal are shown, the sulphur varying from 2.13 to 4.80 and the ash from 4.72 to 10.16. The average composition of the dry organic matter in the samples examined is as follows:

	Corrected for sulphur.	Not corrected for sulphur.
Carbon	81.86	83.06
Hydrogen	5.64	5.74
Nitrogen	1.50	1.52
Oxygen	11.00	9.68
	100.00	100.00
Sulphur	......	3.26

The average calorific value of the coal as determined is considerably higher than the calorific value as calculated by Dulong's formula, and this relation exists through all the samples examined with one exception in which the two are practically identical. The value of "H" as determined for the seam or the heating value of the coal free from ash, sulphur and moisture as determined from the average of all the analyses is 8363 calories.

It will be noted that in the calorific value of the individual samples recalculated from the value of "H" considerable variations occur amounting in one case to 3.8 per cent., from the values determined in the calorimeter. It appears that in the samples in the southern part of the state the heating values calculated from the average all run lower than those actually determined while in the northern portion of the state they run higher.

In so far as a conclusion would be warranted from the limited number of samples analyzed, this would indicate that the heating value of the actual coal was higher in the southern portion than in the northern portion of the state. The number of samples of this coal taken was not sufficient to indicate with certainty local variations in the field and the ultimate analysis and calorific value of any particular sample would only be applicable to the neighborhood of the location of the sample taken.

The Middle Kittanning or No. 6 Coal.

The samples of No. 6 coal cover a territory extending from Lawrence County near Ironton in a direction slightly east of north up to Coshocton, from thence in a more easterly direction nearly to Alliance on the border of Columbiana County. The first important group is principally located in the eastern part of Hocking, the western part of Athens, the whole of Perry and through Muskingum County. The second important group of samples covers Coshocton and Tuscarawas Counties. Scattered samples only, represent the rest of the field.

The average composition of the dry organic matter is as follows:

	Corrected for sulphur.	Not corrected for sulphur.
Carbon	81.68	82.88
Hydrogen	5.68	5.77
Nitrogen	1.50	1.51
Oxygen	11.14	9.84
	100.00	100.00
Sulphur	......	3.30

In order to investigate which of these two statements applies best to the No. 6 coal, the determination of the composition of the dry organic matter of four coals among those highest in sulphur, Nos. 101, 133, 114, and 117 in the tables of analyses, were compared in the same way with four of the low sulphur samples, Nos. 89a, 83, 90, and 86. The results are as follows:

Not Corrected for Sulphur.

	Average 4 high sulphur.	Average 4 low sulphur.
Carbon	82.98	81.60
Hydrogen	5.98	5.51
Nitrogen	1.48	1.60
Oxygen	9.56	11.29
	100.00	100.00

Corrected for Sulphur.

	Average 4 high sulphur.	Average 4 low sulphur.
Carbon	81.02	81.36
Hydrogen	5.83	5.49
Nitrogen	1.45	1.55
Oxygen	11.70	11.60
	100.00	100.00

It will be seen from these examples that the composition of the organic matter after the correction for sulphur is practically identical in these coals, which would justify the conclusion that most of the sulphur in the No. 6 coal was present in the form of iron pyrites and that the ultimate analysis of the two sets of samples was quite constant if based on the dry organic matter. The value of "H" or the heating value of the combustible in the seam is 8243. The calorific value for the average of the seam as determined by Dulong's formula is 45 calories below the average of the determinations in the calorimeter, equivalent to six-tenths of one per cent. It will be noted that in the great majority of cases the results by Dulong's formula correspond quite closely to the determination in the calorimeter.

The calorific values of the individual samples derived from the value of "H" for the seam, with a few exceptions, agree fairly closely with the determinations made in the calorimeter. There are several wide variations, however. To one of these attention has been called before. The next largest variation is in sample No. 119. The field notes show that all the coal in this mine is more or less red or weathered, though the sample cut was as yet black on the butts. The coal is soft and cuts easily and crumbles. There is but one bench. Sample 137, which also falls widely out of line, is in Columbiana County and far removed from the rest of the field and seems to indicate as far as a single sample can, that the coal had changed markedly in character at that point. With these exceptions the value of "H" agrees fairly well in the different samples.

The samples of No. 6 coal vary in sulphur all the way from 5.60 down to .51. A study of the location of the samples together with the determination of sulphur indicates that the percentage of sulphur in the coal varies somewhat regularly with the geographical location of the samples, the few samples taken in Lawrence and Gallia Counties running between three and four per cent. in sulphur. Passing north to the Hocking field, the samples from the adjoining townships, Ward in Hocking County, Blacklick and Monroe in Perry County and Trimble in Athens all show less than 1½ per cent. and in most cases less than one per cent. of sulphur, indicating a large area of low sulphur coal.

South and west of this area of low sulphur, the sulphur contents increases ranging from 1½% to 3% in the northern part of Athens County, the eastern part of Hocking and the central part of Perry County. Going to the north the sulphur in the samples increases rapidly reaching a high sulphur area in the southern part of Muskingum County, in which the samples run from four to five per cent. and over. The sulphur is high, in the rest of the field only passing below 3 per cent. m one sample occurring in Coshocton County, becoming very high again in the northeastern part of Coshocton County, where it again reaches a maximum of over five per cent. From this point north the sulphur again drops until in the northern part of Tuscarawas and southern part

of Stark the samples run under three per cent. These results indicate clearly that the distribution of the sulphur in the No. 6 coal is not erratic but passes with more or less regularity from well defined points of low sulphur in the seam to points of maximum sulphur.

If the heating value of the individual samples calculated from "H" be compared with the actual calorimeter determination in these different districts, it will be noticed that in the Hocking valley region of low sulphur, the values calculated from "H" are uniformly above those determined from the calorimeter, agreeing rather closely in the amount. This shows that the low sulphur coals in this district had lower heating values for the actual combustible than some of the high sulphur coals in the more northern part of the state.

The following table gives the average composition of the six low sulphur Hocking Valley samples, Nos. 86, 87, 88, 90, 79 and 91, two of the Muskingum County samples, 101 and 96, three of the high sulphur group in Coshocton County, 114, 117 and 133, and in the low sulphur group 138, 126 and 135.

	First low sulphur group. Hocking field.	Muskingum Co., High sulphur.	Coshocton Co. High sulphur.	Second or northern low sulphur.
Moisture	7.37	5.05	4.24	6.24
Ash	5.96	9.66	9.24	6.61
Sulphur	0.97	5.76	5.39	2.73
Carbon	69.96	65.81	67.44	70.23
Hydrogen	5.50	5.30	5.31	5.47
Nitrogen	1.33	1.13	1.21	1.24
Oxygen	16.28	12.34	11.42	13.73
Calories determined	6947	6780	6869	7084
Calories from "H"	7086	6685	6808	7020
Value of "H"	8080	8360	8320	8320

The value of "H" is calculated for each group from the average of the group.

The value of "H" given here should be used in estimating the heating value of samples of the Hocking Valley coals and will give more correct results than using the value of "H" for the whole seam. The increase in the heating value of the coals that are high in sulphur may be due either to the fact that too low a rating is given to the combustion of sulphur through making no allowance for iron burned at the same time or to an actual higher heating value of the combustible material of the coal in these coals. The composition of the dry organic matter in these portions of the No. 6 seam calculated from the foregoing averages is given in the following table both corrected for sulphur and not corrected for sulphur.

Composition of the dry combustible.

Not Corrected for Sulphur.

	6 Hocking Valley samples.	Muskingum Co. samples.	High Sulphur group, Coshocton Co.	Northern low sulphur group.
Carbon	81.64	82.76	83.14	83.20
Hydrogen	5.46	5.96	5.96	5.67
Nitrogen	1.55	1.41	1.47	1.46
Oxygen	11.35	9.87	9.43	9.67
	100.00	100.00	100.00	100.00
Sulphur	0.97	5.76	5.39	2.73
Corrected for Sulphur.				
Carbon	81.34	80.58	81.14	82.22
Hydrogen	5.44	5.80	5.83	5.62
Nitrogen	1.49	1.37	1.39	1.41
Oxygen	11.73	12.25	11.64	10.75
	100.00	100.00	100.00	100.00

These figures show that the northern group after correcting for sulphur was noticeably lower in oxygen and higher in carbon than the Hocking Valley coals, indicating a distinct change in the character of the coal from the southern to the northern part of the seam and corresponding to the indication in the calorimeter. It is interesting to notice a similar change in the percentage of moisture found in these coals, this being noticeably higher in the southern part of the state than in the northern, as would be expected from the higher oxygen contents of the coal and decrease in carbon.

The analysis of the No. 6 coal would seem to warrant the conclusion that the changes in the quality of the coal are not erratic or abrupt but progressive and that the analysis of the tables could be applied with considerable confidence to determine the character of the coals in the vicinities of the points sampled.

The fixed carbon in the No. 6 coal averages 48.96%. The average ratio of volatile matter to fixed carbon is 1.29 as compared with 1.31 for the No. 5 coal and 1.15 for the Clarion coal. The variation of this ratio for different samples of the same coal is very considerable. Taking the average of the six samples of the Hocking Valley coal given above, the ratio of volatile matter to fixed carbon is 1.54; for the three Coshocton County samples the ratio of volatile matter to fixed carbon is 1.18. In the latter group the calorific values determined from "H" are all considerably below the calorimeter results, which in the Hocking valley group

they are all considerably above, showing that the low ratio of fixed carbon to volatile matter in the Coshocton County coals goes with a marked increase in the value of the heating power of the organic material of the coal. This ratio, the so-called "fuel ratio," first proposed years ago by Dr. Ashburner, would appear to be no indication of the relative heating value of the combustible material in this seam.

The Upper Freeport or No. 7 Coal.

The samples representing the No. 7 coal form two groups: (1) being the Waterloo coal in the northern part of Lawrence and southwestern part of Gallia Counties; (2) the northern No. 7 in which most of the samples are located in Muskingum covering a small area east of Zanesville. One sample was taken in Coshocton County nearly due north of the Zanesville group.

The average calorific value of the southern group of samples is 6504 calories, 106 calories higher than calculated by Dulong's formula from the average of the coals. The value of "H" is 8074 calories and the heating value of the individual samples calculated from this value of "H" agrees very closely with the heating value as determined by the calorimeter, showing the general character of the combustible organic matter to be practically uniform throughout the small group composing the Waterloo field. The average composition of the dry organic matter calculated as before is as follows:

	Corrected on the assumption that sulphur is all present as pyrites.	Not corrected for sulphur.
Carbon	80.93	81.52
Hydrogen	5.36	5.40
Nitrogen	1.57	1.58
Oxygen	12.14	11.50
	100.00	100.00
Sulphur	......	1.62

The ratio of fixed carbon to volatile matter for the southern group is 1.53. It will be noticed that this group of coals agrees very closely in fuel ratio with the Hocking valley group of the No. 6 coal, and it agrees with it quite closely in the composition of the dry organic matter calculated on the sulphur free basis and still more closely when calculated on the analysis not corrected for sulphur.

Corrected for Sulphur.

	Southern Group No. 7.	Hocking Valley Group No. 6.
Carbon	80.93	81.34
Hydrogen	5.36	5.44
Nitrogen	1.57	1.49
Oxygen	12.14	11.73
	100.00	100.00
Sulphur	......	......
Not Corrected for Sulphur.		
Carbon	81.52	81.64
Hydrogen	5.40	5.46
Nitrogen	1.58	1.55
Oxygen	11.50	11.35
	100.00	100.00
Sulphur	1.62	0.97

The value of "H" for the samples of the Hocking Valley group of the No. 6 coal is 8080 and for the Waterloo coal 8074.

The northern group of samples of the No. 7 coal are markedly higher in sulphur and lower in moisture, the change in this respect corresponding to the change in the No. 6 coal as it passes to the northern part of the state. In these northern samples the "fuel ratio" also falls to 1.18, following in this respect the large drop in "fuel ratio" in the No. 6 coal in the northern portion of the field. The composition of the dry organic matter in the No. 7 coal in the northern field is as follows:

	Corrected for sulphur.	Not corrected sulphur.
Carbon	80.86	82.25
Hydrogen	5.77	5.87
Nitrogen	1.49	1.50
Oxygen	11.88	10.38
	100.00	100.00
Sulphur	......	3.80

It will be noticed that after correcting for sulphur the analysis from the two fields are nearly identical, but by correcting for sulphur there is quite a marked difference in the percentages of carbon and oxygen. The average sulphur in the northern samples is more than double that in the southern samples. The value of "H" for the northern samples is 8280, which would apparently correspond to a low oxygen and a higher carbon content. In the northern coals as in the southern the average heating value calculated by Dulong's formula is noticeably lower than the heating value determined in the calorimeter. The agreement in individual samples between the heating value calculated from "H" and the heating value determined in the calorimeter is fairly satisfactory.

The three samples taken in the southern part of Mushingum County are all very high in sulphur as compared with the samples in the southern district. A single sample taken in Coshocton County is lower in sulphur, higher in moisture and approximates more nearly in analytical character to the samples in the southern part of the state, having the high "fuel ratio" shown in that district.

The Pittsburg or No. 8 Coal.

The samples representing this coal cover the southern part of Gallia County, where a small number were taken, part of Athens County, all of Belmont, the southeastern part of Harrison and the southern part of Jefferson Counties. The samples form three general groups representing detached fields of the No. 8 coal. Four samples in Gallia County are high sulphur coals and show more heating value as determined by the calorimeter than is given by calculation from Dulong's formula.

The average value of "H" for all of the samples of the Pittsburg seam is 8363. The heating values of the Gallia County samples calculated from this value all exceed very decidedly the heating values observed in the calorimeter. The small group of samples taken in Athens and Morgan Counties are very close in general analytical character to those taken in Gallia County, being high in sulphur and moisture. The correspondence between the results by Dulong's formula and the results from the calorimeter is fairly close and they agree with the samples from Gallia County in that all the values derived from "H" are noticeably higher than those determined in the calorimeter. These facts would indicate that the No. 8 coal in these localities was distinctly different in analytical character and heating value from the Belmont County district. The composition of the dry organic matter in the coal calculated from the average of the whole seam is as follows:

	Corrected for sulphur.	Not corrected for sulphur.
Carbon	82.31	83.73
Hydrogen	5.58	5.68
Nitrogen	1.36	1.37
Oxygen	10.75	9.22
	100.00	100.00
Sulphur	......	3.81

The sulphur in the samples from the southern and western portions of Belmont County is in all cases over 4%. In the western part of Harrison and south-western part of Jefferson, there appears to be a circumscribed area covering Athens, Short Creek, Mt. Pleasant, Smithfield and Wayne townships, in which the coal is considerably lower in sulphur, most all of the samples containing under 3% and a number of them under 2%. The moisture in the samples from the Belmont district is considerably lower than in the samples from the southern part of the field, as appears to be the case in the other seams of coal extending through the state. The general analytical difference between the samples of the Belmont County district and those from the southern portion of the state in Athens and Gallia Counties is shown by the following table:

	Average South. Athens & Gallia Co. Nos. 25-22 in table.	Average North. Belmont District Nos. 9-17 in table.
Moisture	6.39	4.13
Volatile Matter	36.58	36.27
Fixed carbon	47.06	50.78
Ash	9.97	8.81
Sulphur	4.31	3.64
Hydrogen	5.17	5.21
Carbon	65.53	70.15
Nitrogen	1.01	1.17
Oxygen	14.00	11.02
Calories determined	6604	7101
Calories by Dulong's	6571	7069
Calories from "H"	6731	......
Difference by Dulong's	—0.50	......
Difference from "H"	+1.92	......

The composition of the dry organic matter the value of "H" and the "fuel ratio" for the two groups are as follows:

Corrected for Sulphur.

	No. 8 South.	No. 8 North.
Carbon	80.94	82.78
Hydrogen	5.51	5.60
Nitrogen	1.28	1.35
Oxygen	12.27	10.27
	100.00	100.00
Value of "H"	8202	8412
Fuel ratio	1.28	1.40
Not Corrected for Sulphur.		
Carbon	82.58	84.08
Hydrogen	5.62	5.69
Nitrogen	1.31	1.42
Oxygen	10.49	8.81
	100.00	100.00

The Pomeroy or No. 8a Coal.

The samples representing this coal cover a small area in Meigs County and the north-eastern portion of Gallia County around Pomeroy. With one exception the samples are only moderately high in sulphur. The average heating value of the samples calculated by Dulong's formula falls about nine-tenths of a per cent. below the heating value determined in the calorimeter. There is considerable variation among the individual samples, but in most cases the heating value determined is noticeably in excess of the heating value as calculated by the formula. The value of "H" or the heating value of the dry combustible matter is 8156 and in no case does the heating value of the individual sample depart more than one per cent. from the heating value calculated from the value of "H," showing considerable uniformity in the quality of the combustible material. The ultimate analysis of the dry organic matter with the oxygen uncorrected and corrected for sulphur is as follows:

	Corrected for sulphur.	Not corrected for sulphur.
Carbon	80.58	81.50
Hydrogen	5.72	5.78
Nitrogen	1.32	1.32
Oxygen	12.38	11.40
	100.00	100.00
Sulphur	......	2.42

The fuel ratio or fixed carbon divided by volatile matter is 1.37, but this ratio varies very markedly in the different samples. In sample No. 30, the fuel ratio is 1.55 and in Sample No. 33, it is 1.27. It is noticeable that the one with the low fuel ratio shows a higher heating value in the calorimeter than the results calculated from the average and the one with the high fuel ratio shows a lower result in the calorimeter than when calculated from the average.

The Meigs Creek or No. 9 Coal.

The territory covered by the samples of this coal forms two well defined areas:—the first, occupies the northern part of Washington, the eastern part of Morgan and most of Noble counties, including a more or less circular field. The second group covers Belmont County and the south-eastern part of Harrison County, most of the samples lying in Belmont. The average calorific value of all the samples as determined in the calorimeter is 6800 calories. The calorific value calculated by Dulong's formula is 41 calories lower or six-tenths of a per cent. The value of "H" or the heating value of the combustible figured from the whole seam is 8379 calories. It will be seen that the majority of the samples when recalculated from the general average agree within one and one-half per cent., only one sample exceeding this amount. The ultimate analysis of the dry organic matter uncorrected and corrected for sulphur is as follows:

	Corrected for sulphur.	Not corrected for sulphur.
Carbon	81.77	83.40
Hydrogen	5.68	5.80
Nitrogen	1.23	1.25
Oxygen	11.32	9.55
	100.00	100.00
Sulphur	......	4.28

Considering the two groups of samples separately the average sulphur of the southern or Morgan and Noble County group is 5.30, for the northern or Belmont County group 2.88 per cent., the samples from the more northern portion of this latter field being very noticeably lower in sulphur. The average analysis of the dry organic matter for the two fields both corrected and uncorrected for sulphur are as follows:

The Southern or Morgan and Noble County Group.

	Corrected for sulphur.	Not corrected for sulphur.
Carbon	81.76	83.38
Hydrogen	5.82	5.94
Nitrogen	1.12	1.14
Oxygen	11.30	9.54
	100.00	100.00
Sulphur	......	5.30

The Northern or Belmont County Group.

	Corrected for sulphur.	Not corrected for sulphur.
Carbon	82.61	83.50
Hydrogen	5.54	5.60
Nitrogen	1.39	1.40
Oxygen	10.46	9.50
	100.00	100.00
Sulphur	......	2.88

The southern group is noticeably higher in oxygen and lower in carbon in the analysis after correction for sulphur, though the two groups correspond very closely if the correction for sulphur is omitted. The average moisture of the southern group is distinctly lower than in the northern portion of the field. The fuel ratio of the No. 9 coal for the average of the whole seam is 1.34. This ratio, however, varies widely in the different samples of coal and apparently is not connected in any way with variations in the heating value. The ash contents does not appear to vary in any regular way with the location of the samples.

GENERAL CONCLUSIONS.

The foregoing review of the analytical results which are given in full in the tables that follow would seem to indicate that the moisture, sulphur and heating value of the various seams were tolerably constant in particular portions of the seam, but that they changed somewhat systematically from one general portion of the seam to another. This conclusion is of importance as it warrants the application of the published analyses with reasonable confidence in estimating the quality of the coal in the neighborhood of the location from which the individual samples were taken. Of course, it is not claimed that the law is rigid, but that there is sufficient correspondence to give considerable confidence in the application.

ANALYTIACAL TABLES.

CLARION OR NO. 4 COAL.

Publication No.	County.	Township.	Moisture at 105° C.	Volatile Matter.	Fixed Carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calorific value determined.	Calorific value calculated by Dulong's formula.	Calorific value calculated from "H". "H" = 8223.	Variation of value by Dulong's formula from actual determination. Percent.	Variation of value from "H" from actual determination. Percent.
65	**Lawrence**	Decatur	6.34	35.30	40.95	17.41	5.29	4.91	57.92	1.07	13.40	5967	5914	5954	—0.90	—0.20
67	"	"	5.86	37.25	41.61	15.28	5.36	5.06	60.22	1.18	12.90	6185	6175	6165	—0.20	—0.30
68	"	"	6.11	38.43	45.52	9.94	3.61	5.42	65.53	1.22	14.28	6643	6631	6687	—0.20	+0.70
66	"	Washington ..	6.00	39.16	42.98	11.86	5.10	5.26	63.32	1.22	13.24	6519	6475	6450	—0.70	—1.10
64	**Scioto**	Bloom	6.80	37.92	45.94	9.34	3.45	5.33	65.30	1.23	15.35	6535	6528	6690	—0.10	+2.40
63	**Jackson**	Madison	4.90	35.75	45.65	13.70	6.14	4.89	62.57	1.23	11.47	6386	6386	6327	0	—0.90
62	"	Bloomfield ...	5.31	37.33	43.82	13.54	6.08	4.98	62.05	1.23	12.12	6323	6346	6310	+0.40	—0.20
55	"	Milton	5.61	38.92	47.38	8.09	3.70	5.47	67.30	1.28	14.16	6821	6794	6875	—0.40	+0.80
56	"	"	4.98	39.71	45.51	9.80	4.08	5.39	66.14	1.28	13.31	6752	6720	6764	—0.50	+0.20
57	"	"	4.71	40.51	46.17	8.61	3.73	5.44	67.51	1.26	13.45	6867	6834	6905	—0.50	+0.60
60	"	"	5.33	41.01	45.26	8.40	3.72	5.50	66.52	1.28	14.58	6781	6726	6872	—0.80	+1.30
59	**Vinton**	Wilkesville ...	4.72	39.88	44.19	11.21	4.16	5.36	65.01	1.28	12.95	6694	6637	6665	—0.90	—0.40
61	"	" ...	4.52	40.10	46.53	8.85	4.23	5.44	67.17	1.28	13.03	6854	6834	6871	—0.30	+0.30
54	"	Vinton	5.02	40.31	46.51	8.15	2.81	5.49	68.52	1.28	13.69	6927	6903	6969	—0.40	+0.60
58	"	"	4.61	41.35	42.94	11.10	5.28	5.36	64.91	1.30	12.05	6696	6694	6616	0	—1.20
70	"	Madison	5.02	39.90	46.11	8.97	3.32	5.48	67.92	1.33	12.98	6960	6895	6875	—0.90	—1.20
69	"	Elk	4.95	39.17	46.56	9.32	3.53	5.40	67.17	1.30	13.28	6914	6797	6838	—1.70	—1.10
	Average	....	5.34	38.94	44.92	10.80	4.33	5.30	65.01	1.25	13.31	6637	6605	6637	—0.50	0

LOWER KITTANNING OR NO. 5 COAL.

Publication No.	County.	Township.	Moisture at 105° C.	Volatile Matter.	Fixed Carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calorific value determined.	Calorific value calculated by Dulong's formula.	Calorific value calculated from "H". "H" = 8363.	Variation of value by Dulong's formula from actual determination. Percent.	Variation of value from "H" from actual determination. Percent.
74	Lawrence	Perry	7.57	38.51	45.13	8.79	3.20	5.59	66.71	1.27	14.44	6777	6764	6799	−0.20	+0.30
75	"	Elizabeth	8.07	34.54	47.68	9.71	2.13	5.44	65.54	1.23	15.95	6626	6533	6746	−1.40	+1.80
76	Jackson	Milton	8.39	35.18	49.01	7.42	2.65	5.47	66.63	1.37	16.46	6772	6621	6879	−2.20	+1.60
71	Perry	Pike	6.85	35.22	47.77	10.16	4.72	5.26	64.78	1.22	13.86	6591	6557	6652	−0.50	+0.90
72	"	"	6.74	37.05	49.09	7.12	2.58	5.47	68.34	1.24	15.25	6885	6808	7046	−1.10	+2.30
73	Muskingum ...	Washington ..	5.05	39.75	47.43	7.77	4.80	5.37	68.07	1.18	12.81	6983	6908	6997	−1.00	+0.20
77b	Jefferson	Knox	2.46	38.48	51.66	7.40	3.82	5.38	74.20	1.27	7.93	7591	7589	7305	0	−3.80
77	Tuscarawas ...	Sandy	5.30	38.73	48.26	7.71	3.25	5.46	69.75	1.18	12.65	7168	7044	7076	−1.70	−1.30
77a	Mahoning	Green	5.23	36.86	53.19	4.72	2.17	5.50	73.84	1.41	12.36	7502	7378	7398	−1.70	−1.40
	Average	....	6.18	37.15	48.80	7.87	3.26	5.44	68.65	1.26	13.52	6988	6911	6988	−1.10	0

MIDDLE KITTANNING OR NO. 6 COAL.

Publication No.	County.	Township.	Moisture at 105° C.	Volatile Matter.	Fixed Carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calorific value determined.	Calorific value calculated by Dulong's formula.	Calorific value calculated from "H", "H"=8243.	Variation of value by Dulong's formula from actual determination.	Variation of value from "H" from actual determination.
															Percent.	Percent.
136	Lawrence	Perry	5.99	39.05	50.14	4.82	3.61	5.56	71.82	1.33	12.86	7314	7248	7135	—0.90	—2.40
82a	"	"	6.64	34.28	48.16	10.92	3.32	5.16	64.95	1.23	14.42	6626	6483	6597	—2.20	—0.40
82b	Gallia	Greenfield ...	8.08	37.53	45.87	8.52	3.64	5.48	65.71	1.18	15.47	6717	6614	6657	—1.50	—0.90
89a	Athens	Canaan	6.36	34.19	50.96	8.49	0.51	5.40	69.25	1.43	14.92	6919	6822	6988	—1.40	+1.00
83	"	Athens	6.17	36.40	49.61	7.82	0.90	5.43	69.22	1.30	15.33	6868	6823	7036	—0.70	+2.40
84	"	Waterloo	6.70	35.36	51.19	6.75	2.28	5.49	69.21	1.18	15.09	6921	6885	6997	—0.50	+1.10
85	"	"	6.80	36.90	48.25	8.05	2.14	5.49	67.40	1.37	15.55	6794	6717	6891	—1.10	+1.40
82	Vinton	Swan	4.90	39.16	45.79	10.15	4.25	5.40	66.26	1.23	12.71	6845	6762	6748	—1.20	—1.40
81	Hocking	Starr	6.52	38.30	47.15	8.03	3.52	5.49	67.33	1.20	14.43	6850	6792	6832	—0.80	—0.20
89	Athens	Dover	7.14	34.22	51.92	6.72	1.65	5.56	69.32	1.30	15.45	6863	6889	7001	+0.40	+2.00
90	"	Trimble	7.28	32.38	53.61	6.73	0.86	5.45	69.46	1.34	16.16	6894	6813	7036	—1.20	+2.10
86	Hocking	Ward	7.55	34.03	52.57	5.85	0.77	5.52	70.05	1.42	16.39	6950	6874	7092	—1.10	+2.00
87	"	"	7.45	35.01	52.73	4.81	0.66	5.53	71.04	1.43	16.53	7057	6949	7193	—1.50	+1.90
88	"	"	7.40	34.17	53.43	5.00	1.06	5.55	70.58	1.32	16.49	7027	6930	7157	—1.40	+1.80
80	"	Green	6.55	37.30	49.18	6.97	2.57	5.45	68.40	1.18	15.43	6901	6798	6975	—1.50	+1.10
79	Perry	Salt Lick	7.76	33.50	51.27	7.47	1.45	5.46	68.30	1.18	16.14	6772	6737	6901	—0.50	+1.90
91	"	Monroe	6.79	35.45	51.85	5.91	1.00	5.49	70.30	1.30	16.00	6983	6906	7137	—1.10	+2.20
78	"	Pike	7.00	37.12	48.93	6.95	2.33	5.58	68.29	1.26	15.59	6880	6821	6953	—0.90	+1.10
92	"	"	5.25	38.85	46.04	9.86	3.43	5.38	66.05	1.18	14.10	6773	6663	6792	—1.60	+0.30
93	"	Bearfield	5.90	36.58	47.42	10.10	4.96	5.26	65.43	1.22	13.03	6686	6649	6627	—0.60	—0.90
95	"	Clay	6.72	38.30	48.34	6.64	2.43	5.61	68.45	1.29	15.58	6903	6847	6996	—0.80	+1.30
94	"	Harrison	7.21	37.60	49.93	5.26	2.34	5.60	69.77	1.26	15.77	7008	6942	7075	—0.90	+1.00
97	"	"	5.70	38.83	47.02	8.45	3.38	5.37	67.77	1.18	13.85	6851	6807	6874	—0.60	+0.30

MIDDLE KITTANNING OR NO. 6 COAL.

Publication No.	County.	Township.	Moisture at 105° C.	Volatile Matter.	Fixed Carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calorific value determined.	Calorific value calculated by Dulong's formula.	Calorific value calculated from "H". "H" = 8243.	Variation of value by Dulong's formula from actual determination. Percent.	Variation of value from "H" from actual determination. Percent.
98	"	"	6.40	38.00	48.02	7.58	2.72	5.49	68.06	1.26	14.89	6867	6811	6927	—0.80	+0.90
101	Muskingum	Brush Creek	5.08	39.75	45.40	9.77	5.54	5.32	65.74	1.14	12.49	6802	6732	6687	—1.00	—1.70
100	"	Harrison	4.67	40.32	45.18	9.83	4.10	5.38	67.71	1.16	11.82	6873	6838	6802	—0.50	—1.00
96	"	Newton	5.02	38.16	47.26	9.56	5.97	5.29	65.88	1.12	12.18	6758	6757	6683	0	—1.10
99	"	Washington	5.44	39.15	46.13	9.28	3.77	5.34	67.16	1.18	13.27	6822	6781	6804	—0.60	—0.30
104	"	Muskingum	5.55	40.27	48.95	5.23	3.63	5.57	70.54	1.26	13.77	7191	7108	7137	—1.00	—0.80
102	"	Madison	4.75	39.88	46.09	9.28	5.35	5.35	66.69	1.28	12.05	6854	6834	6766	—0.30	—1.30
103	"	"	4.62	40.95	47.85	6.58	4.49	5.47	69.58	1.30	12.58	7126	7066	7051	—0.80	—1.10
111	Coshocton	Linton	4.37	40.97	49.30	5.36	3.61	5.56	71.34	1.28	12.85	7247	7207	7224	—0.60	—0.30
112	"	"	10.93	34.00	48.43	6.64	2.03	5.37	63.08	1.15	21.73	6133	6054	6673	—1.30	+8.80
108	"	Franklin	4.33	41.11	48.97	5.59	4.00	5.41	71.42	1.22	12.36	7269	7194	7186	—1.00	—1.10
109	"	Virginia	5.12	38.99	48.87	7.02	3.87	5.45	69.49	1.20	12.97	7066	7022	7010	—0.60	—0.80
105	"	Jackson	5.32	40.93	47.45	6.30	4.22	5.50	69.29	1.24	13.45	7086	7010	7032	—1.10	—0.80
110	"	Lafayette	5.60	34.69	46.43	13.28	4.87	4.95	61.59	1.08	14.23	6222	6179	6395	—0.70	+2.80
113	"	Oxford	4.44	40.71	50.40	4.45	3.54	5.53	72.65	1.35	12.48	7351	7318	7298	—0.40	—0.70
114	"	Adams	4.58	39.18	47.49	8.75	5.36	5.40	67.51	1.24	11.74	6878	6930	6823	+0.80	—0.80
118	"	White Eyes	5.32	37.39	48.69	8.60	4.36	5.32	67.41	1.18	13.13	6828	6813	6834	—0.20	+0.10
120	"	"	4.50	38.73	50.80	5.97	3.63	5.53	70.94	1.30	12.63	7173	7174	7163	0	—0.10
107	"	Keene	5.40	39.92	49.60	5.08	3.18	5.58	70.90	1.24	14.02	7194	7121	7189	—1.00	—0.10
133	Tuscarawas	Salem	3.45	40.02	48.86	7.67	5.22	5.30	70.02	1.26	10.53	7135	7148	7013	+0.20	—1.70
131	"	Clay	3.41	39.73	47.48	9.38	4.88	5.23	68.77	1.30	10.44	6971	7018	6896	+0.70	—1.10
115	"	Jefferson	4.72	40.30	49.51	5.47	4.05	5.53	71.08	1.32	12.55	7199	7199	7160	0	—0.50
130	"	Mill	3.78	38.27	49.53	8.42	3.83	5.26	70.31	1.22	10.96	7101	7108	7008	+0.10	—1.30

MIDDLE KITTANNING OR NO. 6 COAL.

129	"	Union	3.81	38.71	51.47	6.01	3.24	5.41	72.30	1.36	11.68	7306	7276	7239	—0.40	—0.90
124	"	Warwick	4.10	41.64	49.05	5.21	3.25	5.57	72.45	1.42	12.10	7331	7326	7281	—0.10	—0.70
134	"	York	3.18	43.56	46.33	6.93	4.12	5.50	71.13	1.28	11.04	7305	7260	7163	—0.60	—1.90
116	"	Bucks	5.19	40.79	48.15	5.87	3.55	5.59	70.12	1.36	13.51	7122	7090	7119	—0.40	0
128	"	Auburn	4.30	40.07	48.00	7.63	3.97	5.41	69.39	1.28	12.32	7001	7030	7021	+0.40	+0.30
117	Coshocton	Crawford	4.70	39.20	44.81	11.29	5.60	5.23	64.78	1.12	11.98	6594	6647	6589	+0.80	—0.10
106	"	Clark	5.30	39.08	49.47	6.15	3.72	5.50	69.59	1.12	13.92	7084	7003	7077	—1.10	—0.10
121	Tuscarawas	Dover	3.52	40.25	50.22	6.01	3.17	5.41	72.13	1.28	12.00	7297	7248	7267	—0.70	—0.40
122	"	"	4.94	36.20	49.36	9.50	4.19	5.14	67.54	1.30	12.33	6856	6793	6801	—0.90	—0.80
123	"	Goshen	3.51	41.60	47.20	7.69	4.56	5.45	70.26	1.22	10.82	7153	7192	7047	+0.50	—1.50
132	Carroll	Orange	3.76	39.11	50.34	6.79	3.06	5.36	71.99	1.40	11.40	7238	7241	7190	0	—0.70
138	Tuscarawas	Fairfield	7.15	38.34	49.95	4.56	2.62	5.64	71.29	1.23	14.66	7194	7129	7121	—0.90	—1.00
127	"	"	4.66	39.25	49.87	6.22	3.28	5.48	70.80	1.28	12.94	7097	7126	7150	+0.40	+0.70
119	Holmes	Walnut Creek	7.31	34.92	53.56	4.21	1.00	5.42	70.62	1.44	17.31	6952	6852	7234	—1.40	+4.10
125	Tuscarawas	Lawrence	4.69	39.57	46.68	9.06	4.70	5.30	67.59	1.24	12.11	6881	6873	6828	—0.10	—0.80
126	"	Sandy	4.92	38.13	49.91	7.04	2.91	5.40	70.45	1.28	12.92	7082	7062	7082	—0.30	0
135	Stark	Sandy	6.66	36.24	48.88	8 22	2.66	5.37	68.94	1.20	13.61	6977	6897	6857	—1.10	—1.70
137	Columbiana	Liverpool	3.60	36.16	55.64	4.60	1.76	5.46	77.06	1.38	9.74	7789	7728	7462	—0.80	—4.20
139	Stark	Minishillen	5.65	38.51	45.76	10.08	4.13	5.29	66.92	1.19	12.39	6868	6791	6699	—1.10	—2.50
	Average		5.56	38.11	48.96	7.36	3.30	5.43	69.03	1.26	13.62	6980	6935	6980	—0.60	0

UPPER FREEPORT, WATERLOO OR NO. 7 COAL.

Publication No.	County.	Township.	Moisture at 105° C.	Volatile Matter.	Fixed Carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calorific value determined.	Calorific value calculated by Dulong's formula.	Calorific value calculated from "H". "H" = 8074.	Variation of value by Dulong's formula from actual determination. Percent.	Variation of value from "H" from actual determination. Percent.
147	Lawrence	Lawrence	7.20	32.25	49.88	10.67	2.33	5.03	65.03	1.25	15.69	6556	6365	6496	—2.90	—0.90
144	"	Aid	7.85	32.90	47.07	12.18	2.66	5.09	63.03	1.25	15.79	6305	6228	6302	—1.20	0
145	"	"	8.37	31.80	51.60	8.23	1.29	5.21	66.94	1.31	17.02	6596	6502	6658	—1.40	+0.90
146	"	"	8.45	31.25	49.02	11.28	0.93	5.10	65.20	1.28	16.21	6405	6348	6427	—0.90	+0.30
142	Gallia	Walnut	7.62	32.85	47.14	12.39	1.81	5.19	63.48	1.28	15.85	6371	6276	6353	—1.50	—0.30
140	Lawrence	Symmes	7.13	33.65	50.31	8.91	1.31	5.33	67.09	1.28	16.08	6716	6595	6703	—1.80	—0.20
141	"	"	8.77	31.70	50.82	8.71	0.76	5.32	66.88	1.25	17.08	6586	6520	6618	—1.00	+0.50
143	"	"	8.38	31.45	49.97	10.09	1.84	5.18	64.90	1.27	16.72	6497	6351	6477	—2.30	—0.30
	Average	....	7.97	32.23	49.48	10.31	1.62	5.18	65.32	1.28	16.30	6504	6398	6504	—1.60	0

UPPER FREEPORT OR NO. 7 COAL.

Publication No.	County.	Township.	Moisture at 105° C.	Volatile Matter.	Fixed Carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calorific value determined.	Calorific value calculated by Dulong's formula.	Calorific value calculated from "H". "H"=8280.	Variation of value by Dulong's formula from actual determination. Percent.	Variation of value from "H" from actual determination. Percent.
148	Muskingum ...	Harrison	4.89	42.35	44.98	7.78	4.36	5.53	67.74	1.17	13.42	6944	6899	6968	—0.60	+0.30
149	" ...	Brush Creek..	4.72	43.47	44.25	7.56	5.00	5.55	68.27	1.32	12.30	7046	7010	6962	—0.50	—1.20
150	" ...	Wayne	5.11	35.50	46.79	12.60	3.84	5.11	64.81	1.25	12.39	6558	6551	6582	—0.10	+0.30
151	Coshocton	Clark	6.40	37.92	52.49	3.19	2.01	5.67	72.72	1.25	15.16	7325	7217	7365	—1.50	+0.70
	Average	....	5.28	39.81	47.13	7.78	3.80	5.47	68.38	1.25	13.32	6968	6919	6969	—0.70	0

PITTSBURG OR NO. 8 COAL.

Publication No.	County.	Township.	Moisture at 105° C.	Volatile Matter.	Fixed Carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calorific value determined.	Calorific value calculated by Dulong's formula.	Calorific value calculated from "H", "H" = 8363.	Variation of value by Dulong's formula from actual determination Percent.	Variation of value from "H" from actual determination. Percent.
25	Gallia	Ohio	5.80	36.76	47.38	10.06	4.34	5.16	64.94	1.10	14.40	6551	6504	6772	—0.70	+3.40
27	"	Harrison	6.98	36.14	47.85	9.03	5.21	5.24	64.91	1.01	14.60	6583	6540	6705	—0.70	+1.90
28	"	"	7.83	34.15	48.26	9.76	3.89	5.18	64.59	1.09	15.49	6544	6423	6655	—1.90	+1.70
26	"	Green	6.73	34.34	45.90	13.03	4.37	5.11	62.30	1.14	14.05	6356	6287	6443	—1.10	+1.40
23	Athens	Ames	5.78	37.43	48.79	8.00	4.19	5.14	67.55	0.95	14.17	6833	6714	6954	—1.70	+1.80
24	"	Berne	6.60	35.05	48.15	10.20	3.41	5.13	66.61	0.93	13.72	6607	6639	6750	+0.50	+2.20
24	"	"	4.51	38.24	45.76	11.49	4.88	5.10	65.92	0.99	11.62	6636	6691	6727	+0.80	+1.40
22	Morgan	Homer	6.87	40.55	44.39	8.19	4.22	5.32	67.39	0.90	13.98	6722	6770	6846	+0.70	+1.80
9	Belmont	Washington ..	2.79	37.88	49.91	9.42	5.09	5.25	69.76	1.09	9.39	7215	7156	7031	—0.80	—2.60
11	"	Somerset	4.08	37.08	48.23	10.61	4.95	4.89	68.77	1.10	9.68	6931	6937	6831	+0.10	—1.40
8	"	Mead	2.91	37.94	51.15	8.00	4.31	5.11	72.95	1.04	8.59	7340	7386	7187	+0.60	—2.10
3	"	Pultney	3.51	38.65	50.98	6.86	3.76	5.45	72.06	1.17	10.70	7325	7322	7266	0	—0.80
4	"	"	3.80	37.18	50.07	8.95	4.27	5.23	70.57	1.20	9.78	7103	7181	7036	+1.10	—0.90
7	"	Smith	3.21	36.82	52.71	7.26	4.28	5.14	71.49	1.06	10.77	7297	7177	7225	—1.60	—1.00
10	"	Warren	4.47	37.53	46.99	11.01	4.67	5.17	67.64	1.08	10.43	6875	6908	6783	+0.50	—1.30
6	"	Union	3.75	37.99	47.42	10.84	4.76	5.09	67.41	1.11	10.79	6865	6844	6852	—0.30	—0.20
5	"	"	4.46	36.00	48.78	10.76	4.45	4.85	68.24	1.10	10.60	6903*	6825	6818	—1.10	—1.20
1	"	Pease	3.39	36.84	51.91	7.86	2.97	5.21	71.45	1.24	11.27	7217	7148	7241	—1.00	+0.30
2	"	Colerain	3.79	36.37	50.84	9.00	4.16	5.14	70.41	1.09	10.20	7145	7114	7039	—0.40	—1.50
6a	"	Wheeling	4.25	33.53	51.87	10.35	3.95	5.19	68.17	1.09	11.25	6903	6900	6901	0	0
2a	"	Flushing	4.23	36.34	50.22	9.21	4.17	5.14	68.75	1.09	11.64	7003	6919	6984	—1.20	—0.30
12	Jefferson	Mt. Pleasant..	3.10	37.92	49.46	9.52	3.83	5.22	69.56	1.10	10.77	7153	7042	7074	—1.60	—1.10
15	"	Warren	3.13	37.88	50.77	8.22	4.02	5.38	71.03	1.26	10.09	7233	7246	7168	+0.20	—0.90
15a	"	"	4.57	32.40	54.03	9.00	1.55	5.06	71.18	1.32	11.89	7105	7017	7133	—1.30	+0.40

PITTSBURG OR NO. 8 COAL.

18	Harrison	Short Creek ..	6.54	35.48	51.24	6.74	2.19	5.70	70.49	1.22	13.66	7061	7119	7118	+0.80	+0.80
21	"	Athens	5.98	34.35	53.70	5.97	1.35	5.44	72.22	1.31	13.71	7202	7145	7281	—0.80	+1.10
20	"	Cadiz	3.83	36.70	48.59	10.88	4.38	5.09	67.70	1.27	10.68	6864	6861	6865	0	0
16	Jefferson	Wells	4.89	33.10	51.55	10.46	4.09	5.03	68.01	1.12	11.29	6953	6833	6829	—1.70	—1.80
13	"	Smithfield	4.96	34.51	54.08	6.45	1.75	5.37	72.43	1.33	12.67	7277	7199	7301	—1.10	+0.30
19	"	" ...	4.18	36.95	50.65	8.22	2.83	5.36	71.20	1.26	11.13	7160	7180	7153	+0.30	—0.10
14	"	" ...	4.30	35.28	52.54	7.88	3.01	5.18	71.34	1.20	11.39	7144	7125	7160	—0.30	+0.20
17	"	Wayne	5.05	35.88	51.12	7.95	2.61	5.32	70.68	1.25	12.19	7147	7076	7116	—1.00	—0.40
	Average	....	4.70	36.35	49.87	9.10	3.81	5.20	68.99	1.13	11.17	6977	6945	6976	—0.50	0

Calorific value and ultimate analysis on these two samples low — see note accompanying analytical samples given in field report.

POMEROY OR NO. 8a COAL.

Publication No.	County.	Township.	Moisture at 105° C.	Volatile Matter.	Fixed Carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calorific value determined.	Calorific value calculated by Dulong's formula.	Calorific value calculated from "H", "H" = 5156.	Variation of value by Dulong's formula from actual determination. Percent.	Variation of value from "H" from actual determination. Percent.
34	Gallia	Chesire	8.21	34.23	46.10	11.46	2.18	5.48	62.95	1.02	16.91	6387	6297	6423	1.40	+0.60
33	Meigs	Sutton	4.85	36.28	46.35	12.52	2.94	5.32	65.29	1.17	12.76	6624	6624	6565	0	0.90
29	"	Salisbury	7.33	34.59	49.39	8.69	2.05	5.53	66.71	1.06	15.96	6725	6655	6728	1.00	0
30	"	"	7.22	32.82	50.67	9.29	1.32	5.39	64.47	1.10	16.43	6668	6551	6732	1.80	+1.00
31	"	"	5.51	38.19	45.72	10.58	4.17	5.40	65.55	0.95	13.35	6661	6677	6507	+0.20	+1.00
32	"	Rutland	7.03	33.33	48.11	10.93	1.83	5.20	65.29	1.03	15.72	6512	6431	6534	1.20	+0.30
	Average ...	....	6.79	34.91	47.72	10.58	2.42	5.39	65.38	1.06	15.19	6596	6539	6598	0.90	0

MEIGS CREEK OR NO. 9 COAL.

Publication No.	County.	Township.	Moisture at 105° C.	Volatile Matter.	Fixed Carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calorific value determined.	Calorific value calculated by Dulong's formula.	Calorific value calculated from "H", "H" = 8379.	Variation of value by Dulong's formula from actual determination. Percent.	Variation of value from "H" from actual determination. Percent.
53	Washington	Adams	2.95	37.47	46.69	12.89	5.55	5.05	65.88	0.92	9.71	6803	6773	6712	—0.40	—1.30
52	"	Aurelius	3.40	37.95	49.07	9.58	5.03	5.31	68.33	0.90	10.85	7083	6998	6983	—1.20	—1.40
44	Noble	Elk	3.06	38.43	46.18	12.33	6.00	5.11	66.18	0.86	9.53	6865	6834	6722	—0.50	—2.10
45	"	Enoch	2.90	37.24	49.70	10.16	4.27	5.22	68.53	1.04	10.78	7051	6968	7023	—1.20	—0.40
43	"	Stock	2.55	38.40	47.64	11.41	5.79	5.11	67.50	0.92	9.27	6952	6947	6854	—0.10	—1.40
42	"	Marion	3.12	37.36	46.67	12.85	5.60	5.09	65.61	0.92	9.93	6739	6755	6698	+0.20	—0.60
50	Morgan	Meigsville	5.13	36.07	47.06	11.74	4.89	5.06	64.77	0.87	12.67	6625	6541	6666	—1.30	+0.60
48	"	Bristol	5.05	37.83	46.75	10.37	4.30	5.14	67.04	0.89	12.26	6730	6757	6823	+0.40	+1.40
49	"	Manchester	4.07	37.61	47.66	10.66	5.07	5.10	63.19	0.87	12.11	6779	6698	6834	—1.20	+0.80
47	Noble	Brookfield	3.54	37.41	45.82	13.23	6.21	5.12	64.44	0.88	10.12	6642	6679	6593	+0.60	—0.70
46	"	"	4.85	37.28	48.05	9.82	5.59	5.26	66.01	0.97	12.35	6834	6738	6807	—1.40	—0.40
37	Belmont	Warren	4.47	35.31	47.15	13.07	3.27	4.99	65.83	1.13	11.71	6668	6607	6709	—0.90	+0.60
40	"	Goshen	3.40	35.72	45.94	14.94	4.39	4.86	64.77	1.08	9.96	6578	6576	6573	0	—0.10
41	"	Smith	3.52	34.74	49.90	11.84	3.67	5.02	67.36	1.05	11.06	6884	6778	6867	—1.50	—0.20
39	"	Union	4.17	35.09	51.14	9.60	3.11	4.97	69.90	1.09	11.33	7001	6943	7035	—0.80	+0.50
38	"	"	4.31	32.47	51.54	11.68	1.94	5.09	68.32	1.11	11.86	6837	6805	6920	—0.50	+1.20
36a	"	Wheeling	7.52	31.75	49.49	11.24	2.11	5.14	66.41	1.11	13.99	6589	6584	6678	—0.10	+1.40
36	"	Flushing	4.98	33.30	48.90	12.82	2.41	4.95	66.31	1.19	12.32	6652	6584	6740	—1.00	+1.30
35	Harrison	Athens	5.35	33.09	51.27	10.29	2.20	5.21	68.67	1.25	12.38	6885	6860	6933	—0.40	+0.70
	Average		4.11	36.03	48.26	11.60	4.28	5.09	66.74	1.00	11.29	6800	6759	6800	—0.60	0

LABORATORY TESTS ON THE NO. 8 COAL TO DETERMINE ITS SUITABILITY FOR IMPROVEMENT BY WASHING.

The object of coal washing is to remove the impurities—ash and pyrites—from the coal by taking advantage of their greater specific gravity. The various forms of apparatus in use all depend upon the principle that coal being lighter can be carried away by moving water while the heavy impurities—slate and pyrites—are left behind. In order that a coal may be benefited by this treatment two things are necessary:

In the first place, the pyrites and the slate must be so distributed that by crushing the coal to a reasonable fineness they may be broken away from the pieces of coal. Second, the coal left must be purified enough to make the expense of the process worth while. In order to test these points what are known as "float and sink" tests are made in the laboratory, the coal being crushed sufficiently small and then separated by sifting into two or three sizes, these sizes are then stirred up in a heavy liquid of such specific gravity that the coal will float upon it while the impurities will sink. In this way the coal is separated from the free pyrites and slate, the relative amounts weighed and the products analyzed to ascertain the degree of purification.

In the experiments the following routine was adopted. The coal was crushed so that it would pass a one-half inch screen. The crushed coal was then freed from dust by separating from it all that would pass a one-sixtieth inch screen. This is best done by, first, screening on a twenty-mesh sieve and then screening what passes through the twenty-mesh on a sixty-mesh, subsequently adding the oversize of the sixty-mesh to the oversize of the twenty-mesh. The portion of coal passing through the sixty-mesh sieve amounting to from one to four per cent. of the total weight of the sample was not treated farther as the separation by gravity is very unsatisfactory on this dust. The solutions used in the separation were, first, calcium chloride of 1.35 specific gravity, and second, zinc chloride solution of 1.45 specific gravity.

Coking tests were made upon the coal on both the separated and the unseparated samples. The laboratory method of making the coking test is as follows: Two clay crucibles are selected of such size that one sets easily inside the other. Convenient sizes are a 20-gram Denver fire-clay for the inner and a larger 5 Hessian for the outer. The inner crucible is provided with a closely fitting cover. The larger crucible is put into a wind furnace and heated to a bright red. Meanwhile the smaller one is charged about two-thirds full with coal crushed to about ¼ inch mesh. (Using the 20-gram Denver crucible one hundred grams of coal can be weighed out for the charge.) The cover is placed on the smaller crucible and it is set inside the larger one. A little coarse coal is thrown on top of it and the cover placed on the larger crucible. At the end of an hour

both are removed from the furnace. A little more coal is put into the outer crucible and it is allowed to cool covered. The placing of the coal in the outer crucible is to prevent oxygen getting into the coke and burning out sulphur.

The results of the washing and coking tests are given in the following tables. The results may perhaps best be understood by consideration of some particular sample, as No. 4. In this sample the percentages of ash and sulphur in the unwashed coal are respectively 9.12 and 4.35. The sample crushed to ½ inch was separated by sifting into 96.9 coarser and 3.1 per cent. finer than 60-mesh. This coarser portion treated on a solution of 1.35 specific gravity resulted in a separation into 81.15 per cent. of light coal which analyzed 5.09 per cent. ash and 2.63 per cent. sulphur. The heavier portion analyzed 25.74 per cent. ash and 11.04 per cent. sulphur. 5.09 per cent. of ash in the light product shows the possibility of producing a washed coal low in ash. The washing loss—14.99 per cent.—heavier than 1.35, is larger than desirable, but results upon samples No. 12 and No. 11 washed on a solution of 1.45 specific gravity indicate that the ash might be reduced to about 7 per cent. with a washing loss of probably only 6 or 7 per cent. An improvement of 2 per cent. in ash accompanied by decided lowering of the sulphur with a washing loss of only 6 or 7 per cent. indicates the commercial possibility of putting washed coal from this region upon the market.

Coking tests were made upon both the raw or unwashed coal and upon the washed product and the yield and ash and sulphur contents determined. The coke yield in this unwashed sample is 62 per cent. analyzing 13.35 per cent. ash and 3.47 per cent. sulphur. The coke yield from the washed product is 59.2, which analyses 9.36 per cent. ash and 1.91 per cent. sulphur.

All of the samples show a decided lowering in ash by washing and a considerable lowering of the amount of sulphur. In most of the samples, however, a large amount of sulphur seems to be present as an inherent part of the coal and cannot be removed by washing. The ash was very light colored in most of the samples which indicates that only a portion of the sulphur was present as pyrites. Sample No. 29 deserves special notice. The original coal contains 8.94 per cent. ash and 2.11 per cent. sulphur. The washed coal shows only 6.16 per cent. ash and 1.14 percent. sulphur. The coke from the washed coal analyzes only 10.35 percent. ash and .93 per cent. sulphur and compares in these respects very favorably with Connellsville coke. The production of high-grade blast furnace coke from washed coals from some of these mines appears not at all unlikely, while every sample tested shows the possibility of producing from these seams washed coal low in ash.

The extent to which the sulphur in the coal is expelled in coking is a matter of interest. In the table of results which follow is given the percentage of the total sulphur in the original coal which is retained in

the coke produced. The result is obtained by multiplying the percentage yield of the coke by the percentage of sulphur in the coke and dividing the product by the percentage of sulphur in the coal.

Publication No. 12.

Unwashed coal, ash 9.61, sulphur 3.86.

	Portion	Ash	Sulphur	Compared with original sample Ash	Compared with original sample Sulphur
½ inch to $\frac{1}{60}$ inch =	94.5	....	....	....	....
Lighter than 1.35 =	74.9	5.48	3.17	4.10	2.37
Heavier than 1.35 =	19.6	24.23	6.23	4.75	1.22
$\frac{1}{60}$ inch and finer =	4.1	....	....	0.39	0.16
				9.24	3.75
½ inch to $\frac{1}{60}$ inch =	97.7	....	....	....	....
Lighter than 1.45 =	90.1	7.12	3.60	6.42	3.24
Heavier than 1.45 =	7.6	37.73	6.64	2.87	0.50
$\frac{1}{60}$ inch and finer =	2.0	....	....	0.19	0.08
				9.48	3.82

Coke.

	Percentage yield	Ash	Sulphur
Coke from unwashed coal =	61.9	14.58	3.36
Percentage of the sulphur in the coal left in the coke = 53.6%.			
Coke from washed coal lighter than sp. gr. 1.45 =	60.2	12.37	3.22
Percentage of the sulphur in the coal left in the coke = 53.8%.			

Publication No. 19.

Unwashed coal, ash 8.35, sulphur 2.88.

	Portion	Ash	Sulphur	Compared with original sample Ash	Compared with original sample Sulphur
½ inch to $\frac{1}{60}$ inch =	94.49	....	....	....	....
Lighter than 1.35 =	82.42	5.83	2.55	4.81	2.10
Heavier than 1.35 =	12.07	29.06	7.09	3.51	0.86
$\frac{1}{60}$ inch and finer =	4.69	....	....	0.39	0.14
		....		8.71	3.10

Publication No. 19.

Coke.

	Percentage yield	Ash	Sulphur		
Coke from unwashed coal=....	62.00	15.63	2.47		
Percentage of the sulphur in the coal left in the coke = 53.2%.					
Coke from washed coal lighter than 1.35 = ...	59.03	11.32	2.12		
Percentage of the sulphur in the coal left in the coke = 49.0%.					

Publication No. 4.

Unwashed coal, ash 9.12, sulphur 4.35.

	Portion	Ash	Sulphur	Compared with original sample	
				Ash	Sulphur
¼ inch to 1/80 inch =..........	96.14	....	....	....	....
Lighter than 1.35 = ...	81.15	5.09	2.63	4.13	2.13
Heavier than 1.35 =.........	14.99	25.74	11.04	3.86	1.65
1/80 inch and finer =..........	3.1	....	....	0.28	0.13
				8.27	3.91

Coke.

	Percentage yield	Ash	Sulphur		
Coke from unwashed coal =...	62.00	13.35	3.47		
Percentage of the sulphur in the coal left in the coke = 49.4%.					
Coke from washed coal lighter than 1.35 =............	59.29	9.36	1.91		
Percentage of the sulphur in the coal left in the coke = 43.0%.					

Publication No. 10.

Unwashed coal, ash 11.25, sulphur 4.77.

	Portion	Ash	Sulphur	Compared with original sample	
				Ash	Sulphur
¼ inch to 1/80 inch =.........	96.00	....	....	....	....
Lighter than 1.35 = ...	74.75	6.67	3.82	4.99	2.86
Heavier than 1.35 =.........	21.25	23.04	7.86	4.90	1.67
1/80 inch and finer =..........	3.43	....	....	0.39	0.16
				10.28	4.69

Publication No. 11.

Unwashed coal, ash 10.81, sulphur 5.04.

	Portion		Ash	Sulphur	Compared with original sample	
					Ash	Sulphur
½ inch to 1/60 inch = ...	94.52		....	....	....	....
Lighter than 1.35 = ...		66.7	6.48	3.68	4.32	2.45
Heavier than 1.35 = ...		27.82	21.05	8.83	5.86	2.46
1/60 inch and finer = ...	4.62		....	....	0.50	0.23
					10.68	5.14
½ inch to 1/60 inch = ...	96.9		....	....	....	....
Lighter than 1.45 = ...		87.3	7.83	4.20	6.84	3.67
Heavier than 1.45 = ...		9.6	33.88	14.24	3.25	1.37
1/60 inch and finer = ...	2.2		....	....	0.24	0.11
					10.33	5.15

Publication No. 5.

Unwashed coal, ash 10.98, sulphur 4.54.

	Portion		Ash	Sulphur	Compared with original sample	
					Ash	Sulphur
½ inch to 1/60 inch = ...	96.0		....	....	....	....
Lighter than 1.35 = ...		74.15	6.90	3.40	5.12	2.52
Heavier than 1.35 = ...		21.85	24.64	8.55	5.38	1.87
1/60 inch and finer = ...	3.35		....	....	0.37	0.15
					10.87	4.54

Publication No. 9.

Unwashed coal, ash 9.50, sulphur 5.13.

	Portion		Ash	Sulphur	Compared with original sample	
					Ash	Sulphur
½ inch to 1/60 inch = ...	97.0		....	....	....	....
Lighter than 1.35 = ...		75.6	6.93	3.82	5.24	2.89
Heavier than 1.35 = ...		21.4	19.31	9.26	4.13	1.98
1/60 inch and finer = ...	2.0		....	....	0.19	0.10
					9.56	4.97

Coke.

	Percentage yield	Ash	Sulphur	Phos.	
Coke from unwashed coal = ...	59.32	16.22	4.42	.0067	
Percentage of the sulphur in the coal left in the coke = 51.1%.					
Coke from washed coal lighter than 1.35	57.6	12.23	3.24	.0036	
Percentage of the sulphur in the coal left in the coke = 48.8%.					

Publication No. 8.

Unwashed coal, ash 8.07 sulphur 4.35.

	Portion		Ash	Sulphur	Compared with original sample	
					Ash	Sulphur
¼ inch to $\frac{1}{60}$ inch = ...	96.9		....	....	....	....
Lighter than 1.35 = ...		81.5	5.68	3.22	4.63	2.62
Heavier than 1.35 = ...		15.4	24.58	11.44	3.79	1.76
$\frac{1}{60}$ inch and finer = ...	2.8		....	....	0.23	0.12
					8.65	4.50

Coke.

	Percentage yield	Ash	Sulphur	Phos.	
Coke from unwashed coal = ...	60.6	14.36	4.01	.0125	
Percentage of the sulphur in the coal left in the coke = 55.9%.					
Coke from washed coal lighter than 1.35	58.7	10.00	2.71	.0056	
Percentage of the sulphur in the coal left in the coke = 49.4%.					

Publication No. 29.

Unwashed coal, ash 8.94. sulphur 2.11.

	Portion		Ash	Sulphur	Compared with original sample	
					Ash	Sulphur
¼ inch to $\frac{1}{60}$ inch = ...	99.3		....	....	....	....
Lighter than 1.35 = ...		85.5	6.16	1.14	5.27	0.97
Heavier than 1.35 = ...		13.8	27.64	8.83	3.81	1.22
$\frac{1}{60}$ inch and finer = ...	0.5		....	....	0.04	0.01
					9.12	2.20

Coke.

	Percentage yield	Ash	Sulphur	Phos.
Coke from unwashed coal =....	59.86	15.54	1.80	
Percentage of the sulphur in the coal left in the coke = 51.1%.				
Coke from washed coal lighter than 1.35 = ...	59.80	10.35	0.93	.016
Percentage of the sulphur in the coal left in the coke = 48.8%.				

Publication No. 25.

Unwashed coal, ash 10.19, sulphur 4.40.

	Portion		Ash	Sulphur	Compared with original sample	
					Ash	Sulphur
½ inch to 1/60 inch =..........	97.6		....	....	....	....
Lighter than 1.35 =.........		59.4	5.32	2.73	3.18	1.62
Heavier than 1.35 =..........		38.2	18.87	6.94	7.21	2.65
1/60 inch and finer =...........	1.45		....	....	0.15	0.06
					10.54	4.33

Coke.

	Percentage yield	Ash	Sulphur
Coke from unwashed coal =....	58.66	17.15	3.60
Percentage of the sulphur in the coal left in the coke = 48.0%.			
Coke from washed coal lighter than 1.35	57.7	9.32	2.12
Percentage of the sulphur in the coal left in the coke = 44.8%.			

Publication No. 27.

Unwashed coal, ash 9.17, sulphur 5.29.

	Portion		Ash	Sulphur	Compared with original sample	
					Ash	Sulphur
½ inch to 1/60 inch =..........	95.5		....	....	....	....
Lighter than 1.35 =..........		72.0	4.93	3.11	3.55	2.24
Heavier than 1.35 = ...		23.50	23.58	11.00	5.54	2.59
1/60 inch and finer =......... ..	3.4		....	....	0.31	0.18
					9.40	5.01

Coke.

	Percentage yield	Ash	Sulphur		
Coke from unwashed coal =....	59.15	15.56	4.49		
Percentage of the sulphur in the coal left in the coke = 50.2%.					
Coke from washed coal lighter than 1.35	56.50	8.94	2.53		
Percentage of the sulphur in the coal left in the coke = 46.0%.					

CHAPTER IX.

CHEMICAL WORK.

BY PROFESSOR E. E. SOMERMEIER, OHIO STATE UNIVERSITY.

Sampling. The analyses given in this report are all upon mine samples personally taken by representatives of the Survey. A few were collected by Professor Orton, a few by the writer and a few by Mr. D. D. Condit. The greater number were, however, taken by Professor B. A. Eisenlohr and Mr. Jesse E. Hyde, both of whom by their training and experience were unusually well fitted for the work, and their painstaking care in collecting and selecting the samples deserves special acknowledgment.

The method of collecting and handling the samples of No. 4, 5, 6 and 7 coal taken during 1900, 1901, and 1902 was as follows: After an inspection of the mine, a point apparently as nearly representative of the seam as could be obtained was selected for sampling.

The sample was obtained by making a cut across the coal from roof to floor including all the benches of the coal mined and all partings less than three-eighths inch in thickness, but rejecting such impurities as were removed in ordinary work. The cut was from six to eight inches wide by three to four inches deep, care being taken to keep width and depth as nearly uniform as possible. The coal obtained, amounting to from fifty to one hundred and fifty pounds was caught upon a canvas seven feet by seven feet spread upon the floor. This entire sample was transferred to a canvas bag and shipped to the laboratory by freight. Shipped in this way the sample arrived at the laboratory in a partially air-dried condition.

Previous to taking the sample all loose pieces of coal or slate in the seam or roof adjacent to the point to be sampled were dislodged and the section to be sampled straightened up as nearly as possible to a vertical face of fresh coal. In cases where the coal had been exposed for any considerable time the outer exposed portion was removed to a depth of one or two inches before sampling.

The particular conditions under which the sample was taken, the portions of the seam included and the portions rejected in sampling and the analytical results obtained accompanied by the cut of the section of the seam where sampled are given for each sample in that portion of the report prepared by Dr. Bownocker and Professor Orton.

Handling of the Sample in the Laboratory. On arrival of the

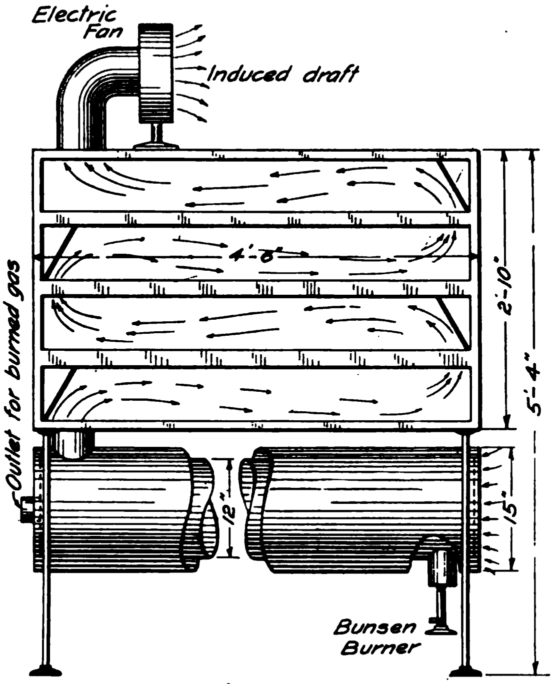
sample at the laboratory it was reduced and quartered by hand and the final portion for analysis ground down on a bucking board till it all passed a sixty-mesh sieve. The analytical work was all done on this partially air-dried sample and the results for moisture on the samples taken in the years 1900, 1901, and 1902 are in all cases lower than the moisture in the coal as mined, and the calorimeter results are likewise higher by an amount proportional to this lower moisture content (in these coals about two or four per cent.), but the results as given are all comparable and probably approximate the moisture content of the coal as marketed under favorable weather conditions.

Method of Sampling Used in Collecting Samples Taken in 1907 of Nos. 8, 8a, and 9 Coal and also a few Samples of No. 5 and No. 6 Coal. The method of collecting these samples is in general similar to the method already described with the exception that the entire sample taken was put through a one-inch mesh sieve and quartered down in the mine and a portion (about 25 pounds) put into a metal can securely sealed and sent to the laboratory by express. Owing to the time and labor involved in quartering down by hand and the difficulty of thorough mixing many of the later samples taken were cut in smaller section (three to four inches by one and one-half to two inches) and the entire sample taken put into the can and shipped to the laboratory. Shipment of the samples to the laboratory in sealed cans prevents moisture loss, and the sample as received represents closely the sample as taken at the mine.

The method of handling the sample in the laboratory is as follows: The 25-pound sample is put through a power jaw crusher and crushed to one-fourth inch. It is then divided by means of a riffie sampler or quartered down by hand to about six pounds, and this six-pound portion spread upon a weighed metal tray 24 by 24 inches and given a preliminary air drying, the loss in weight being recorded as a part of the analytical work done upon the sample. This air-drying treatment is primarily to get the sample into a more constant condition for handling in the laboratory, but it is also of general interest in that it shows the possible loss which may occur during shipment of the coal.

Allowing the coal to arrive at an approximately air-dried condition by simple exposure to the air of the laboratory is a slow process and to expedite the work use is made in the laboratory of a special air dryer in which the trays containing the coal are placed. (P. 312). The air in this dryer is warmed 10 to 15 degrees Centigrade, above the room temperature and kept in constant circulation by means of an electric fan mounted on top of the dryer. In this warmer air the samples rapidly lose their loosely held moisture and at the end of six or eight hours drying at this increased temperature the loss between successive weighings made with an interval of from two to three hours drying usually amounts to less than two or three-tenths of one per cent., and the sample at the end of this time has reached about the same condition as would be attained by drying at atmospheric temperature for three or four days.

This air-dried sample, still further reduced to one-eighth inch by passing through a pair of crushing rolls, is then quartered down till a portion of this product amounting to about three-fourths of a pound is obtained. This portion is then ground to a powder in a closed ball mill jar using quartz pebbles. The jars used are seven inches in diameter by seven inches high inside. The pebbles used are about one inch in diameter. The grinding is accomplished by the pebbles falling over one another, hence to secure best results the speed of rotation of the jars must not be great enough for centrifugal force to overcome the operation of gravity, in which case the pebbles cling to the circumference of the



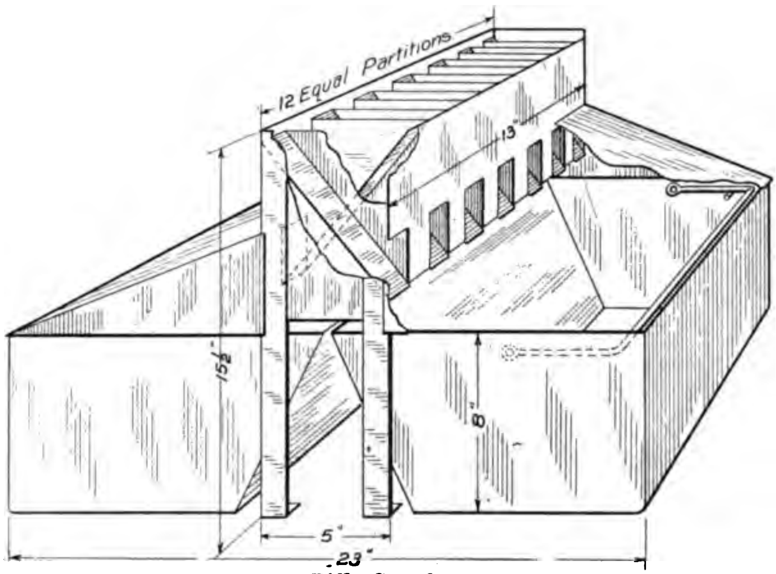
Oven for Air-Drying Coarse Samples..

jar and little or no grinding is effected. In this size jar a speed of from 55 to 60 revolutions a minute gives good results, a three-fourth pound sample being reduced from one-eighth inch to one-sixtieth inch in from 30 to 35 minutes. At the end of the grinding operation the jar is opened and the sample is separated from the pebbles by pouring the contents of the jar upon a coarse sieve.

The fine sample of coal is divided down to about two ounces by passing through a small riffle sampler or the sample is thoroughly mixed by hand with a spatula and about two ounces taken with a sampling spoon from various parts of the material. This two-ounce portion is then put through the 60-mesh sieve, kept well covered during the sifting to prevent moisture changes. A light flat brass ring (about two inches in diameter

and weighing about four ounces) placed in the sieve, is of very great assistance in sifting the sample, preventing caking of the material and clogging of the meshes of the sieve. Usually a few coarse particles, amounting to from one-fourth to one-half per cent. of the sample, remain upon the sieve. These are bucked down by hand on a bucking board and thoroughly mixed with the sifted portion of the sample. The whole is then put in a glass bottle and securely stoppered and constitutes the laboratory sample for analysis.

The jars and pebbles after being cleaned by brushing with a stiff brush, (this part of the operation requiring only a minute or so) are ready for the grinding of another sample of coal. When samples of entirely different material are ground, the jars and pebbles may require more thorough cleansing with water and scrub brush, but. as a rule, in their use for coal, dry cleansing is sufficient.



Riffle Sampler.

The riffle sampler used in reducing the sample is shown in the above figure. Two sizes of sampler are used in the laboratory. The larger size has one-inch subdivisions and is used in reducing the sample from 25 pounds down to the amount to be ground in the ball mill (about three-fourths pound). The sample after grinding in the ball mill is then divided down to about two ounces by means of the smaller sampler having one-half inch subdivisions.

The sampler is essentially a metal box mounted on legs and fitted with a number of equi-distant vertical parallel partitions, the alternate bottoms of the spaces between the partitions sloping in opposite directions. The angle of slope should be about sixty degrees from the horizontal. If much less than this the coal will not run freely and may clog up the sampler.

The lower portions of the sides of the sampler are open and in operation the coal emptied in the top of the sampler runs down the sloping bottoms of the subdivisions and is caught in two buckets below, one-half of the sample being caught in each bucket. To keep down dust the space above the receiving buckets is covered with a metal hood or shield. Three buckets are necessary for convenience in sampling, two to set under the sampler and the third to contain the portion of the sample to be subdivided. After pouring the material through the sampler one of the buckets containing one-half of that poured through is removed and the empty bucket set in its place. The one-half portion is then poured through in turn. The bucket last set under containing one quarter of the original sample is removed and the empty one again set in its place, the subdivision of the sample being continued till the sample is reduced to the amount desired.

After dividing a sample, the sampler is most conveniently cleaned by directing a blast of air from a handbellows through the sub-divisions and any particles of material clinging to the sides or the bottoms of the divisions removed before the apparatus is used for dividing another sample.

METHODS OF ANALYSIS.

The analytical determinations on all of the samples collected during 1901, 1902, and 1903 were made by the writer, who also personally made a considerable number of the determinations upon the samples collected during 1907. Most of the routine analytical work on the 1907 samples was, however, done by Mr. Dana J. Demorest, who by his previous training and experience was well fitted for the work.

The fine samples for analysis are kept in four-ounce wide-mouthed bottles closed with rubber stoppers. Previous to weighing out a portion for an analytical determination the material is thoroughly mixed by giving the bottle fifteen to twenty rotations combined with an upending and tilting movement of the bottle to insure mixing of the top and bottom portions of the sample. For satisfactory mixing in this way the sample should not fill the bottle more than half full. If over two-thirds full the sample should be mixed on paper. After the mixing in the bottle the stopper is removed and the sample still further mixed by means of a sampling spoon and successive small portions then taken till the amount required for the determination is secured, especial care being taken to again securely stopper the bottle before setting aside for other determinations.

Proximate Analysis.

Moisture and Ash. A one-gram portion of the well mixed sample is weighed into an empty capsule and placed for an hour in an oven heated to 105°C. A special double walled oven similar to that used in

PLATE V. Moisture Oven.

the Chemical Laboratory of the United States Geological Survey Fuel Testing Plant was used.

A brief description of this oven is as follows: The inner cylinder is four and one-fourth inches in diameter by seven inches long. The movable perforated shelf fitting in this inner cylinder accommodates six capsules. The outer cylinder or wall is six and one-half inches in diameter by eight inches long. The space between the two cylinders is filled to the top of the inner cylinder with a solution of calcium chloride of such strength that the boiling point of the solution is high enough to raise the temperature of the oven to 105°. Concentration of the solution is prevented by means of a reflux condenser fitted into the top of the oven. Air is admitted into the drying chamber through a coil of block tin tubing which passes through the calcium chloride solution. The inner end of the tubing is soldered into the rear wall of the drying chamber and the outer end is connected to a flask containing concentrated sulphuric acid.

During a determination air under pressure is bubbled through this sulphuric acid, passes through the block-tin coil into the drying chamber and escapes through a small orifice in the door of the oven. The air is passed through at such a rate that a volume equal to the capacity of the oven passes through every six or eight minutes. Most of the moisture of the sample is driven off during the first fifteen or twenty minutes so that by the end of the hour the air in the oven is parctically dried by the sulphuric acid. By working in this way variations in the humidity of the laboratory air do not affect the determinations and duplicates run at different times agree much more closely than where an ordinary air oven is used. At the end of the hour the capsules are removed from the oven, covered, and allowed to cool in desiccators over concentrated sulphuric acid and then weighed covered.

Sulphuric acid gives more concordant results than calcium chloride, as experiments show that if allowed to remain over calcium chloride for any considerable time, the sample dried at 105°C. increases in weight and the results for moisture are correspondingly low. The danger of sulphuric acid splashing up on to the bottom of the capsule when the desiccator is being carried around the laboratory is eliminated by placing a thin sheet of asbestos paper below the capsule, taking care to have it fit so loosely in the desiccator as not to prevent free circulation of air.

Special flat aluminum lids are used in connection with the capsules used in the moisture determinations. They are light and unbreakable, and are much more convenient to handle than the heavy breakable covers ordinarily used with porcelain crucibles. In weighing out the sample at the beginning of the determination the lid is placed upon the balance pan under the empty capsule in which the sample is weighed. The capsules used are heavier and less flaring than the ordinary porcelain crucibles. The dimensions are one inch high by one and five-eighths inch

in diameter at the top. They were obtained from the Henry Heil Chemical Company, St. Louis, and are designated as "porcelain moisture capsules No. 2". They are much more satisfactory for this work than ordinary porcelain crucibles.

After the determination for moisture the sample is burned to ash in a muffle, care being taken to begin the burning off at a low heat to avoid coking of the coal, the temperature of the muffle being raised to redness after the expulsion of the volatile matter. Heating is continued till all black carbon is burned out, the capsule is then removed from the muffle furnace and allowed to cool in the open air and weighed as soon as cooled, it is then replaced in the red-hot muffle for from fifteen to thirty minutes, again allowed to cool and reweighed, continuing this process if necessary till constant weight is obtained.

Volatile Matter. The method used is that recommended by the Committee on Coal of the American Chemical Society. A one-gram sample is weighed into a 30 cc. platinum crucible, the closely fitting lid placed upon the crucible and the whole heated for seven minutes over the full flame of the Bunsen burner, the distance of the crucible from the top of the burner and the height of the burner flame being so adjusted that the entire crucible including the lid is heated to a visible redness during the operation. With artificial gas the distance between the top of the burner and the bottom of the crucible is kept about 7 cm., the free burning Bunsen burner flame being 16 to 20 em. in height. With natural gas a more uniform heating of the crucible is obtained if the distance between the top of the burner and the bottom of the crucible is about 12 cm. and the free burning flame about 30 cm. in height. To prevent air currents from interfering with the determination a cylindrical chimney of asbestos about 15 cm. long by 7 cm. in diameter is used to enclose the burner flame, the triangle upon which the crucible rests being located about 3 cm. below the top of the chimney. This arrangement gives a more uniform heat and more concordant results are obtained.

Fixed Carbon. The Fixed Carbon is the difference between 100 and the sum of the moisture, ash and volatile matter.

Sulphur. The Eschka method was used on all samples. To check these, duplicate determinations were made on the washings from the calorimeter determinations. The two methods give very closely agreeing results. The routine of the work by the Eschka method is as follows: One gram of the well-mixed sample is thoroughly mixed in a 30 cc. platinum crucible with about one and one-half gram of the Eschka mixture (two parts light calcined magnesium oxide plus one part anhydrous sodium carbonate) about one-half gram of the mixture is then spread on top as a cover.

The burning out is done over grain or wood alcohol, gasoline gas or natural gas, experiments having shown that the sulphur contained in gasoline gas and natural gas is so small in amount that little or none

of it is taken up by the Eschka mixture. Ordinary artificial gas is so high in sulphur that its use is not permissible, as blanks are likely to be large and variable and consequently the correction to be applied is uncertain. At the beginning the flame is kept low until the volatile matter is burned out. This requires from fifteen to thirty minutes. The heat is then increased and the mixture stirred occasionally with a platinum wire, the heating being continued till all traces of unburned carbon have disappeared.

The mixture in the crucible is then transferred to a 200 cc. beaker and digested with 75 cc. of water for at least 30 minutes. The solution is then filtered and the residue washed twice with hot water by decantation and then washed on the filter, small portions of water being used for each of the washings until the filtrate amounts to 200 cc. Bromine water in excess is then added, and the solution made slightly acid with hydrochloric acid. The amounts of these reagents usually added are 4 cc. of water saturated with bromine and 3 cc. of concentrated hydrochloric acid.

The solution is heated nearly to boiling and the sulphur precipitated with 20 cc. of a hot five per cent. solution of barium chloride, slowly added from a pipette during constant stirring. The solution and precipitate are allowed to stand at a temperature a little below boiling for two hours or longer before filtering. The filtrate from the barium sulphate is tested for acidity by means of litmus paper, and for excess of barium chloride by adding a few drops of dilute sulphuric acid to a few cc. of the filtrate in a test tube. The preliminary washing of the precipitate is done with hot water containing 1 cc. of hydrochloric acid per liter. The final washings are made with hot water alone and the washing is continued until the washings no longer react for chlorine when tested with silver nitrate.

The precipitate is ignited in a porcelain crucible. The filter and precipitate are placed in the crucible, precipitate uppermost, and the filter folded only enough to prevent loss by spattering. A low heat is used until the paper is entirely "smoked off." The heat is then raised sufficiently to bring the precipitate to dull redness, and the heating continued for a few minutes, or until the carbon is burned out. The crucible and precipitate are then cooled and weighed. The weight of barium sulphate less the blank from the reagents, multiplied by .137 equals the amount of sulphur in the sample.

Ultimate Analysis.

The ultimate analyses were made in regular 25-burner combustion furnaces. Our experience is that the accuracy of the results obtained are largely dependent upon the manipulation and skill of the chemist making the determination, and details and description of the method of

work are not out of the way here, although the process itself is so well known.

The purifying train through which the air and oxygen are passed before they enter the combustion tube are arranged in duplicate, one part for air, the other for oxygen. The purifying reagents, arranged in the order named, are sulphuric acid, potassium hydroxide, soda lime and granular calcium chloride. The combustion tubes are about forty inches long and about five-eighths inch internal diameter. The tube extends beyond each end of the furnace for a distance of about four inches, the ends of the tube being protected from the heat of the furnace by closely fitting circular shields of asbestos. The rear end of the tube (the end next to the purifying train) is closed with a rubber stopper. This end of the tube being kept cool by the protection of the circular shield and by the passage of cool air and oxygen, there is very little danger of volatile products being given off by the rubber. The other end of the tube is closed by a well-rolled cork of specially selected quality, the danger from overheating at this end of the tube being too great to permit of the use of the more convenient rubber stopper.

The rear end of the tube for a distance of ten inches inside the furnace is left empty; the next fourteen inches is filled with a loose layer of wire copper oxide, with a plug of acid-washed and ignited asbestos at either end to hold the oxide in place. The copper oxide is followed by a layer about four inches in length of coarse fused lead chromate, to stop sulphur products, this being held in place by a final plug of asbestos.

The absorption train is as follows: The water is absorbed in a six-inch U tube, filled with granular calcium chloride; the carbon dioxide is absorbed by potassium hydroxide in an ordinary Liebig bulb, to which is attached a three-inch U tube containing soda lime and calcium chloride, the bulb and U tube being weighed up together. This is followed by a final guard tube filled with calcium chloride and soda lime. The gases formed during combustion are drawn through the train by suction, a Marriott bottle being used to secure a constant suction head.

The oxygen used is kept over water and is supplied under small pressure. The supply of oxygen and the aspiration during a combustion are so regulated as to keep the difference in pressure between the inside and outside of the tube very small, the pressure inward being slightly greater. This reduces the danger of leaks to a minimum, and, if by chance any slight leakage does occur, it is inward rather than outward and the effect upon the determination is small.

Before beginning the determination the apparatus is tested for leaks by starting the aspirator and shutting off the supply of air. With the aspirator on full if not more than four or five bubbles of air per minute pass through the potash bulb, the connections are sufficiently tight to proceed with the determination. Air is then admitted to the purifying apparatus, the tube heated to redness throughout and 1000 cc. or more

of air aspirated. The potash bulb and drying tube are then detached and weighed. They are again connected up and 500 cc. of oxygen followed by 1000 cc. of air aspirated through the train.

On commencing the second aspiration the burners under the rear portion of the tube are gradually turned down and finally entirely out. so that the empty portion of the tube into which the sample for analysis is to be inserted becomes nearly or quite cool, by the time the aspiration is complete. The burners under the two-thirds of the copper oxide next to the lead chromate are kept lighted and this portion of the oxide kept at a red heat. After aspiration of the 1000 cc. of air, the potash bulb and drying tube are detached and again reweighed. If the gain or loss in weight is less than .5 mg. the apparatus is ready for an analysis.

The absorption apparatus is then again connected up and two-tenths gram of the well-mixed sample weighed into a platinum boat and the boat and sample pushed into place in the combustion tube as quickly as possible and slow aspiration of the train started at the rate of one or two bubbles a second through the potash bulbs and a mixture, in the proportion of about two bubbles of oxygen to one of air, admitted into the train through the purifying apparatus. The burners under the remaining copper oxide and behind the boat are lighted and the moisture and volatile matter gradually driven off.

This part of the operation requires very careful watching and manipulation to secure correct results. The copper oxide must be at a good red heat or the combustion of the hydrocarbons is very liable to be incomplete. If the evolution of the hydrocarbons is too rapid incomplete combustion or absorption also results. Also if the evolution is too rapid back pressure is developed in the train and losses are almost sure to occur either from moisture getting back into the tube of the purifying apparatus or from slight leaks in the train. When the volatile matter is expelled that portion of the tube containing the boat is heated to redness, more oxygen is admitted into the train and the fixed carbon gradually burned off, using care not to allow the combustion to take place too rapidly or fusion of the ash and incomplete combustion may result.

Oxygen is admitted for about two minutes after the fixed carbon is burned out, which may be seen by the sudden disappearance of the glow. The oxygen is then turned off and air aspirated through the train, the burners under the rear portions of the tube being gradually turned down and out. After 1000 cc. have been aspirated the absorption apparatus is detached and weighed. One-ninth the increase in the weight of the drying tube equals the hydrogen and three-elevenths of the increase in the weight of the potash bulb equals the carbon from the sample. The absorption apparatus is again connected up, the platinum boat removed from the tube. the ash carefully examined for complete combustion and another two-tenths gram sample of coal weighed out for another determination.

Nitrogen. This determination was made by the regular Kjeldahl method, using concentrated sulphuric acid with metallic mercury. This process is too well known to need any particular description here other than mention of the fact that long digestion is necessary to secure complete oxidation. The digestion should be continued for at least three-fourths of an hour after the oxidation is apparently complete. In a bituminous coal if the sample be finely ground the total time for digestion is about three hours.

Calorimeter Determinations.

The calorimeter determinations were all made in the Mahler calorimeter. This calorimeter, the most widely used of the oxygen type, is now well known. A brief description of its construction and details of its operation and the method of calculating results are as follows: Plate VI. shows the important portions of the apparatus. The steel cylindrical bomb in which the combustion takes place has a capacity of about 600 cc. It is fitted with a removable lid to which the platinum tray upon which the sample is placed is attached. Connected to the lid are two platinum rods leading to the tray and to one of which it is attached, these rods being insulated from one another in the lid.

The ignition of the sample is secured by the burning of a small spiral of iron wire (weighing about 13 mg.) attached to the two platinum rods and bent down till it is nearly or quite in contact with the coal. After the sample and ignition wire are in place, the lid is screwed on the bomb and securely tightened, leakage being prevented by means of a lead gasket between the top of the bomb and the lid. Oxygen under pressure (supplied to the trade in steel cylinders at about 100 atmospheres pressure) is now admitted into the bomb through the valve stem, 18 to 20 atmospheres being used. The lower portion of the stem is fitted with a needle valve, which, after the proper amount of oxygen has been admitted, is closed by giving the bomb about one-half turn, very little force being required to close it if the valve is in working order.

After filling the bomb with oxygen, 2400 grams of water are poured into the brass bucket, which is then placed inside the insulated jacket. The bomb is then placed inside the brass bucket containing the 2400 grams of water and the stirrer for agitating the water during combustion fitted into the place. Wires for completing the electric circuit through the platinum rods and ignition wire inside the bomb are attached to terminals on the lid of the bomb.

The thermometer for recording temperature increase is clamped into place and so adjusted that the lower end of the mercury bulb is about two inches above the bottom of the bucket. The thermometer is graduated to one-fiftieth degree Centigrade and is read through a reading telescope set up about five feet distant. For convenience of operation this telescope is fitted to a sliding cathetometer. By the use of this cathetometer the rise of the mercury column during combustion is easily followed through the telescope.

PLATE VI. Mahler Calorimeter with Reading Telescope and Lamp Bank Resistance.

After all attachments have been properly made, the water in the bomb is kept in circulation by means of the stirring apparatus and minute readings of the thermometer taken till a definite regular rate of gain is established. The electric circuit is then completed by closing a switch and the combustion takes place. This is followed by a very rapid increase of temperature for several minutes, after which the change in the system becomes small. The minute readings are continued till this rate of change is also established.

The observed increase of temperature together with the rates of gain or loss at the beginning and end of the operation in connection with the water equivalent of the apparatus and water used furnish all the data for calculating the calories of heat developed during the combustion. This calculation may possibly best be shown by a typical determination giving the results obtained.

GEOLOGICAL SURVEY OF OHIO.

Sample No. 516. Date, 11/4/07

Wet and dry bulbs = 12-22 °C.
Jacket Water = 21 °C. Coal = 1.0018 gms.

Time.	Readings:				
7–50	19.318				21.744°
51	19.326				19.348°
52	19.334	+.0075 rate of change.			
53	19.340			Observed temperature change =	2.396°
54	19.348	+.0075		Radiation loss =	.0093
			+.0026		
½	20.2	+.0030		Corrected temperature change =	2.4053
			+.0001	Water Equivalent 1° =	2875.
55	21.40	—.0025			
			—.0034		5750.0
56	21.700	—.0043			1150.0
			—.0043		00.0
57	21.746	—.0043			14.4
			—.0043		.9
58	21.744	—.0043			
59	21.740		—.0093	Calories of heat developed =	6915.3
60	21.736			Corrections =	100.1
1	21.734	—.0043 rate of change.			
2	21.728			Heat from sample =	6815.2
3	21.722			Correction for excess sample	
4	21.718			over 1 gram =	12.2
				Calorific value of coal =	6803.0

Wire fuse = 10 cm. = 13 mg.
Wire fuse, unburned = 2 cm.
Wire fuse, burned = 8 cm. = 10.4 mg. (1 mg. = 1.7 cal.) = 17.7 cal.
Titer 23.8 to 31.6 = 7.8 cc. (1 cc. = 5 cal.) = 39.0 cal.
Sulphur in coal 3.34% (.01 gm. = 13 cal.) = 43.4 cal.
TOTAL CORRECTION = 100.1 cal.
Thermometer used, No. University 25°. Position 5 cm.
Room temp. — 22°
Atm. oxy. used — 18 Valve, light.
At 19° added 4.5 cc. of water to obtain 2400 grams.
(Signed) E. E. S.

Checked by E. S. D.

The complete record includes the following points: Room temperature, wet and dry bulb readings, temperature of the water in the outer jacket of the calorimeter; pressure in atmospheres of the oxygen in the bomb; condition of the valve of the bomb, thermometer used and its position in the calorimeter during a determination, that is, the distance of the lower end of the bulb above the bottom of the calorimeter bucket, two inches being taken as the standard distance. In beginning a determination minute readings are taken until a regular rate of change has been established. This usually requires only five or six readings, but occasionally seven or eight. When the initial rate is established the combustion is begun at the time of the next minute reading by closing the switch completing the electric current. During the first minute after ignition half-minute readings are taken, after which minute readings are taken until a final rate of change has been established. This usually requires about six readings, but occasionally as many as ten are taken.

The temperture taken for the beginning of the combustion is the reading taken at the time of the burning of the wire fuse. For the end of the combustion period the first temperature reading is taken, which falls well within the established final rate. Some chemists adopt an arbitrary time of five minutes as the combustion period, but in our opinion better and more concordant results are obtained if allowance is made for variations incident to the determination by selecting for the end of the combustion period a temperature which falls in line with the final series of readings.

The corrections applied to the combustion period are obtained by taking into consideration that the changes in the rate of gain or loss in temperature are proportional to the changes in temperature. From this proportion the rate of gain or loss at the beginning and end of each interval of time is found.

In the typical determination given the current was turned on and the combustion started at the beginning of the 54th minute. The increase in temperature during the four minutes preceding is 19.348—19.318=.030° or .0075° per minute. After the beginning of the combustion the temperature increases rapidly, reaching a maximum at the 58th minute, after which there is a rather regular fall during the next seven minutes. Inspection shows the rate of loss to be about .0040° per minute. The reading at the 58th minute is the first reading which falls in line with this rate of change and is therefore taken as the reading for the end of the combustion period.

The observed temperature increase is the difference between the temperature at the beginning and end of the combustion period, 21.744—19.348=2.396°. The loss during the six minutes following the combustion period is 21.744—21.718=.026 or .0043° per minute. The total change in the rate of gain or loss in the system corresponding to 2.39° increase in temperature is a change from a rate of +.0075 to a rate of--

.0043 or a total change of .0118°. A change in rate of .0118° with a change in temperature of 2.39 is equivalent to a change in rate of approximately .0005° for each .1° temperature change, from which the rate of gain or loss at the differnt readings can be obtained. At 54½ minutes the temperature change is (counting to the nearest tenth degree) nine-tenths of a degree equal to a change in rate of nine times .0005=.0045 As the total change was from a plus to a minus rate, this amount will have to be subtracted from the plus rate at the 54th minute. +.0075—.0045 =.0030. At the 55th minute the change is 2° equivalent to a rate change of .010. +.0075—.010=—.0025. The temperature at the 56th and 57th minute being practically the same as that of the 58th minute, the rate of change is the same—.0043.

The actual temperature gain or loss for each of the different intervals is found by adding the rates at the beginning and end of the interval and dividing by two if a minute interval or by four if a half-minute interval. The sum of the rates at the beginning and end of the interval from 54 to 54½ is +.0075+(+.0030)=+.0105. This divided by 4 gives .0026°, the temperature gain during the interval. For the interval 54½ to 55, +.0030+ (—.0025)=.0005. This divided by 4 =+.0001. For the minute interval 55 to 56,—.0025+(—.0043) =—.0068. This divided by 2=—.0034. The losses in the other intervals are obtained in a like manner. Adding together the different gains and losses, the total loss is found to be .0093. The correct temperature change is therefore the observed temperature change increased by this amount 2.396+.0093=2.4053°, the actual temperature change. The water equivalent of the system is 2875 calories. Multiplying the temperature change by this water equivalent (i.e. by the number of calories necessary to cause a rise of 1° of temperature), the total heat developed during combustion is found to be 2.4053x2875=6915.3.

Corrections. The heat from the burning of the wire fuse is found by multiplying the weight of wire taken by its calorific value (1.7 calories for 1 mg.) 10.4 mg. x 1.7=17.7 calories. The acidity of the bomb liquor after combustion is found by titrating it with a standard ammonia of such strength (.0057 grams of ammonia per cc. See acidity corrections) that one cc. corresponds to a heat correction of five calories, assuming the acidity to be entirely due to nitric acid, from which 7.8 times 5 equals 39 calories, the correction due to the formation of nitric acid.

A large part of the acidity in high sulphur coal is, however, due to sulphuric acid, and the heat correction for acid formed, considering it all as nitric acid, is therefore incomplete, a further correction of 13 calories for each .01 gram of sulphur present being required. (See acidity corrections). 3.34 per cent. sulphur in the sample is .0334 grams sulphur on one gram sample taken. Therefore, the correction is 3.34x 13=43 calories.

The total of these corrections is 100.1 calories. 6915.3, the total

heat developed, less this correction of 100.1 gives 6815.2 calories of heat from the combustion of the coal. These 6815.2 calories are developed by 1.0018 grams of sample. The value per gram is therefore 6815.2 divided by 1.0018. The amount of sample taken is so near one gram that this correction can be approximated as .68 of a calorie for .0001 gram of coal. For .0018 the correction is accordingly 18 times .68=12.2. Making this correction gives 6803. as the calorific value of the coal.

SPECIAL NOTES.

Sample for Combustion. In obtaining the sample about two grams are pressed into a small briquette by means of a small screw press and mold (Plate VII.). The press used in connection with this calorimeter work is the iron frame of a two-quart tincture press manufactured by the Enterprise Manufacturing Company, Philadelphia, Pa. In compressing the briquette only sufficient pressure is used to insure the sample holding together, as if the briquettes are pressed too much there is more liability of incomplete combustion. After removal from the mold the briquette is broken into smaller portions and about one gram accurately weighed and put into the platinum tray already mentioned. The pressing of the coal into briquettes prevents loss of fine coal during the filling of the bomb with oxygen, while the breaking of the briquette into smaller pieces has been shown by experience to lessen the liability of incomplete combustion from unburned particles flying out of the tray.

Anthracite coals and cokes cannot be briquetted and are best run by placing a small disc of ignited asbestos upon a platinum tray and then weighing the anthracite or coke directly upon this disc, taking especial care in filling the bomb with oxygen to admit it very gradually in order to prevent particles blowing off of the tray. Efforts to burn coke and anthracite directly upon the platinum tray frequently give low results, possibly explained by the slow burning of the coke and anthracite samples and the rapid conduction of heat by the platinum. The disc by lessening this conduction loss aids in securing completeness of combustion. and higher and more concordant results are obtained by its use.

Preventing Leakage of Valve. By use the valve through which the oxygen is admitted into the calorimeter soon becomes corroded from the action of the acid fumes and rusted through the action of moisture and air. In this condition it is extremely difficult to prevent considerable leakage of oxygen. This leakage may be prevented and the valve made to fit tight by cutting a thin washer of lead about one-thirty-second inch in thickness and fitting into the valve using care in its insertion not to get it in crosswise and thereby close the opening into the bomb. A very efficient way to insert it is as follows: Hold the valve stem, valve-end up and slip the washer over the tip of the needle. Then with the stem in this vertical position screw the lid on to the stem carefully till the washer is pressed into place. Very slight pressure is required to close

PLATE VII. Briquette Press and Equipment for Filling Calorimeter Bomb with Oxygen.

the valve when fitted in this way and extra pressure is to be avoided as tending to force lead into the needle opening, which may be entirely closed and will in this event require drilling out before the bomb can be used again.

Water Surrounding the Bomb. In the regular routine determinations the amount of water used is measured, not weighed. For this purpose a larger Erlenmeyer or Florence flask holding about 2400cc. of water when filled to the middle of the neck is used. The number of grams of water that it delivers is determined by filling it to a fixed mark and weighing at a definite observed temperature. The flask is then emptied and allowed to drain 15 seconds and again reweighed, an allowance of 2.4 grams being made for the effect of the buoyancy of the air displaced by this amount of water. The difference in weight is the number of grams of water the flask delivers at this temperature. A table is then prepared giving for different temperatures the number of cc. of water which must be added to the water inside of the flask to obtain 2400 grams.

The diameter of the neck of the flasks used is from one and one-fourth to one and three-eighths inches. With this size of neck and a uniform time of fifteen seconds for drainage, the amount of water can be measured to an accuracy of 1 cc. or less and errors of measurement do not affect the calorific value obtained over two or three calories. The time required for measuring is less than that required for weighing and does not involve the continued use of an expensive balance and set of weights.

Temperature Conditions. More satisfactory rates of gain or loss during a determination are secured if the temperature differences between the air of the laboratory and that of the water inside the inner bucket and in the outer insulating jacket are kept small. In the laboratory the practice is to keep the temperature of the water in the outer jacket within a few degrees of room temperature. The water to be used in the inner bucket is cooled till its temperature is about two to three degrees lower than that of the water in the outer jacket, care being taken that this temperature is not too near the dew-point. In damp weather to avoid this danger, the water in the outer jacket is kept several degrees above room temperature.

With these temperature relations the greater rate of change during a determination is before the combustion. and the rate of change after the combustion period is small. The larger the rate of change the larger is the possible error. The effects of the larger rate before the combustion period are after the first minute practically eliminated, as by the end of the first minute most of the total temperature rise has occurred and the rate change during the other minutes of the combustion period approximates in value the final rate. With the final rate small the total corrections are correspondingly small and errors from this source are reduced to a minimum.

Acidity Corrections. Data for the correction for formation of nitric and sulphuric acids are as follows: The heat of the formation of aqueous nitric acid is 1058 calories per gram of nitrogen. The heat of the formation of aqueous sulphuric acid is 4450 calories per gram of sulphur. In ordinary combustion of the coal the sulphur is burned to sulphur dioxide, the heat of formation of which is 2250 calories per gram of sulphur. The excess heat due to the formation of sulphuric acid in the bomb is therefore 4450—2250=2200 calories per gram of sulphur.

In neutralization, the reactions are $2HNO_3+NH_4OH=2NH_4NO_3+H_2O$ and $H_2SO_4+2NH_4OH=2(NH_4)_2SO_4+2H_2O$. The strength of the solution of ammonia, such that one cc. equals five calories, based on the heat of formation of nitric acid, is calculated as follows: 1058 calories equals the heat of formation of one gram of nitrogen to aqueous nitric acid, from which five calories equal .00473 grams nitrogen to aqueous nitric acid. One atom of nitrogen as nitric acid neutralizes one molecule of ammonia. Expressed in terms of ammonia, 14:17::.00475:X. X equals .00574 grams ammonia per cc. The relation between sulphuric acid and ammonia is one of sulphuric acid to two of ammonia. One cc. of ammonia solution equals .00574 grams NH_3. Its equivalent strength in sulphur as sulphuric acid is therefore 34:32::.00574:X. X equals .0054 grams sulphur as sulphuric acid. The heat correction for one gram of sulphur is 2200 calories. The correction for .0054 grams is 2200 times .0054, equals 11.9 calories.

It is evident that after multiplying the number of cc. used in the titration by the factor for nitric acid (five calories), it is necessary to make a further correction of 11.9 minus 5 equals 6.9 calories for each cc of ammonia used in titrating sulphuric acid instead of nitric. Since one cc. equals .0054 grams sulphur as sulphuric acid, this corresponds to a correction, for each one-hundredth gram of sulphur, of 6.9 divided by .54=13 calories. The total correction for acidity is obtained therefore by multiplying the cc. of ammonia required by 5 (the factor for nitric acid) and adding 13 calories correction for each one-hundredth gram of sulphur present in the sample.

Ignition of Iron Wire. For igniting the wire fuse used for starting the combustion of the coal a current with an electro-motive force of 15 to 20 volts is desirable. The ignition may be made with lower voltage using the current from a four-cell chromic acid or storage battery or from four or five dry cells in series, but with low voltage, unless special care be taken in wrapping the wire to the platinum terminal rods, failure to ignite often results. If a current of low voltage is used, better contact between the platinum terminals and the iron wire is secured if the rods and wire are carefully cleaned with emery paper and the wrappings of the iron wire around the platinum terminals moistened with a drop of calcium chloride solution. Working in this way, failures of the wire to ignite are reduced to a minimum.

The use of a current of high voltage, as that from a 110 volt lighting circuit, is liable to result in errors. due to heat produced by leakage of current after the ignition of the iron wire. Where current of this high voltage is used, the possible error introduced by using it direct may be eliminated by using a resistance coil connected in parallel with the calorimeter and shunting only a portion of the current through the ignition wire.

In igniting the wire, sufficient current should be used to fuse it in a fraction of a second, as, if the wire is slow in burning, an appreciable amount of heat is radiated from the wire before it finally fuses. The wire ordinarily used with the Mahler calorimeter is about .12 mm. in diameter, ten centimeters weighing about 13 mg. With this size of wire a current of not less than three amperes is desirable.

In the laboratory using the current from a 110-volt lighting circut satisfactory results, as to current and voltage, are obtained by putting as a resistance into the circuit a group of four parallel lamps (32-candle-power) in series with a coil of German silver wire of about five ohms resistance and connecting the wires leading to the calorimeter to the ends of this German silver coil. (Page 329). By this arrangement the difference of potential across the calorimeter after the ignition of the wire is only about 20 volts and the leakage of current is reduced to a negligible amount. With the connection arranged in this way failures of the iron wire to ignite are also very unusual.

In the regular routine of making a determination, the time interval during which there is a possibility of leakage of current is about two seconds, as in burning the wire the switch is kept closed for that length of time. With the arrangement as described frequent tests for leakage were made after completion of a determination by again closing the switch for thirty seconds and taking several additional minute readings of the thermometer. These additional thermometer readings in every case showed little or no variation to have been produced in the rate of temperature change. Similar tests for leakage using the same lamp bank resistance but omitting the German silver coil showed with the switch closed for thirty seconds a leakage of current through the calorimeter sufficiently large in amount in some instances to produce a heating effect of several hundred calories. The insulation of the calorimeter used was afterwards found to be defective and the greater part of the heating effects observed are probably to be attributed to this cause.

The iron ignition wire used (twelve-hundredths of a millimeter in diameter and about two centimeters between the terminals) if in good contact with the platinum terminals has a resistance of less than one ohm and the amount of heat developed during the fraction of a second that current passes through the wire before it ignites is small. The resistance of the calorimeter itself with the insulation in good condition is several millions of ohms. A test on one of the calorimeters indicates a resistance

of upwards of twenty million ohms, the test being made on a 120-volt circuit. Pure water is such a poor conductor that after immersion of the calorimeter in water the resistance is still high (expressed in thousands of ohms).

In routine work the distilled water used to surround the calorimeter bomb is used over and over again. The resistance of this water, owing to traces of impurities, is not so great as that of the original distilled water, but its resistance is still high. Tests usng water which had previouly been used in making forty or fifty calorimeter determinations show with a 120 volt circuit about 1500 ohms resistance. Tests using distilled water taken directly from the laboratory supply showed a resistance of about 5,000 ohms. With the resistance in excess of one thousand ohms, the heating effect due to leakage of current is quite small and the danger from excessive leakage is either from defective insulation of the bomb itself or from the use of water containing more than traces of impurities. The possible heating effects under these conditions are discussed in the next paragraph.

Heat Developed While the Circuit is Closed for Ignition of the Iron Wire. The heat developed in a conductor of which the resistance is R ohms by current of I amperes in a time of t seconds is 0.2387 RI^2t calories.

Using the current from a 110-volt circuit with four candle-power lamps in parallel, the greatest current is approximately four amperes. With the German silver resistance coil (five ohms resistance) in the circuit, the possible heat developed by passage of current through the calorimeter is small. Before the ignition of the iron wire with a low resistance in the calorimeter circuit (a fracton of an ohm) practically all the current passes through the calorimeter, but since I cannot exceed 4, I^2 cannot exceed 16, and with the resistance less than one ohm, the product of .2387 RI^2 is less than four calories per second.

After the ignition of the iron wire under normal conditions the resistance of the calorimeter circuit is expressed in thousands of ohms and practically all the current passes through the German silver coil having only five ohms resistance. Take as a special case the 1500 ohms resistance found in test. With this resistance such a small portion of the current flows through the calorimeter that its heating effect is less than one tenth calorie per second. With defective insulation in the calorimeter or with very impure water, the resistance may be very much less than this and the possible effects under these conditions should be considered.

Take as special cases resistance of ten ohms and one hundred ohms in the calorimeter. With the circuit closed the total current flowing through the resistance coil and the calorimeter is approximately four amperes. This varies slightly on account of small changes in the total resistance of the circuit due to the variations in the calorimeter resistance, but this variation in current is so small that it may be neglected in discussing the heat effect in the calorimeter. With the calorimeter and coil connected in parallel, the portion of the total current passing through

each is inversely as its resistance is to the sum of the two resistances. With ten ohms resistance in the calorimeter and five ohms resistance in the coil the portion of current passing through the calorimeter is

$$\frac{5}{10+5} = \tfrac{1}{3}. \quad \tfrac{1}{3} \text{ of } 4 = 1.3 \text{ amperes.}$$

With 100 ohms resistance in the calorimeter the portion of current passing through it is:

$$\frac{5}{100+5} = \tfrac{1}{21}. \quad \tfrac{1}{21} \text{ of } 4 = .2 \text{ amperes.}$$

Applying the formula for heat production with ten ohms resistance $.2387 \times 10 \times (1.3)^2 = 4$ calories per second. With 100 ohms resistance $.2387 \times 100 \times (.2)^2 =$ one calorie per second.

With resistance between one and ten ohms, the heating effects are very close to four calories. With a resistance of over ten ohms the heating effects are less than four calories per second, from which it appears that using the resistance coil in circuit under no condition can the leakage of current per second be large enough to very appreciably affect the results obtained on the calorific value of the materials tested.

Resistance Coil Left Out of the Circuit. Before the burning of the iron wire with little resistance in the calorimeter (less than one ohm, approximately four amperes of current will pass through the calorimeter and the heating effect is small (less than four calories per second.) After the burning of the iron wire under normal conditions with the resistance expressed in thousands of ohms, the heating effect due to current passing through the calorimeter is also small. In the special test upon the calorimeter showing 1500 ohms resistance, the heating effect of the current flowing through the circuit is between two and three calories per second.

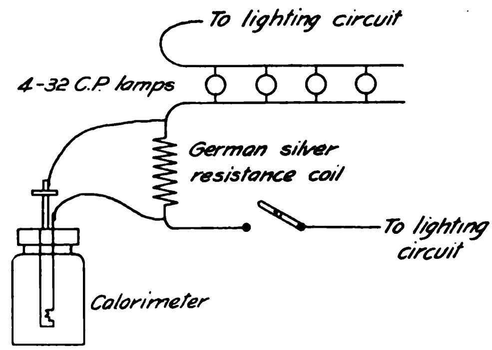


Diagram of Circuit Used in Igniting Wire Fuse.

With the lower resistances, which may occur, due to defects in the insulation or the use of very impure water, the effect may be of considerable magnitude and the possible effects with resistance between one and 1500 ohms should be considered. Small increases in the resistance in the calorimeter diminish the amount of current flowing only slightly and

the amount of heat produced increases very nearly in proportion to the increase in resistance.

With one, two and three ohms resistance in the calorimeter, the heat produced is approximately 4, 8 and 12 calories per second. With larger increases in resistance the change in current due to the change in the total resistance of the circuit should be considered. The total resistance of the circuit is the resistance of the lamps 1/4 (110 ohms) plus the resistance in the calorimeter plus the resistance in the rest of the current. The resistance of the rest of the circuit is small and the total resistance outside the calorimeter is accordingly approximately that of the lamps, 1/4 (110 ohms). The total resistance of the circuit is approximately 27 ohms plus the resistance of the calorimeter.

Ohms law for current flowing through a conductor is $I=\frac{E}{R}$ Considering as special cases the effect of 10, 100 and 1000 ohms resistance in the calorimeter:

(a) With 10 ohms resistance the current is $\frac{110}{27+10}=3$ amperes.

(b) With 100 ohms resistance the current is $\frac{110}{27+100}=.9$ amperes.

(c) With 1000 ohms resistance the current is $\frac{110}{27+1000}=.1$ ampere.

Applying the formula for heat developed in the calorimeter:

(a) $.2387 \times 10 \times (3)^2=21$ calories per second.

(b) $.2387 \times 100 \times (.9)^2=19$ calories per second.

(c) $.2387 \times 1000 \times (.1)^2=3$ calories per second.

With normal conditions, good insulation in the calorimeter and water practically free from impurities, the effects of leakage of current are unimportant, but with defective insulation or water high in impurities, the values obtained under conditions A and B show that the possible effects during the time that the switch is closed for ignition of the iron wire (about two or three seconds) may be of such magnitude (40 to 60 calories) as to appreciably change the calorific value obtained for the materials tested. The use of the resistance coil in the circuit is a safe-guard against such possible errors.

Water Equivalent of the Calorimeter. The accuracy of the calorimetric values obtained is to an important degree dependent upon the accuracy with which the water equivalent of the apparatus has been determined. This may be determined by several methods:

(1) From the weights of the different parts multiplied by their specific heats.

(2) By adding definite weights of warmer or colder water to the system and noting the corresponding increase or decrease in temperature.

(3) By combustion of the same weight of material but varying the amount of water used.

(4) By electrical methods.

(5) By combustion of a substance of known calorific value, as napthalene, benzoic acid or cane sugar.

Four of these methods were tried in determining the water equivalents of the calorimeters used in this work.

First Method: Using the specific heats of the different materials as given by the manufacturer of the apparatus, the water equivalent of one of the calorimetrics used was calculated to be 470 calories. The sources of error are: (1) Any error in the values used for specific heat; (2) the enamel lining cannot be weighed and its weight must be calculated from its surface and approximate thickness and approximate specific gravity. The total amount of enamel is, however, so small, that the error from this source is necessarily small, probably less than one or two calories. (3) Portions of the bomb, bucket and stirrer are not in direct contact with the water and, therefore, are not affected to the same extent as the remainder of the apparatus by a change in the temperature of the water. An arbitrary deduction of three calories was made as a correction for that part of the bucket and stirrer not in contact with the water. This corresponds to about one third the calculated water equivalent of the portion out of water.

The valve stem of the calorimeter is entirely out of contact with the water and is more or less insulated from the lid, and is very little affected by a change in temperature of the water surrounding the bomb. A deduction of 17 calories from the total calculated water equivalent was allowed on this account. After making these two deductions, the value of water equivalent obtained is 470 calories.

Second Method: By adding warmer or colder water to the water surrounding the bomb. As finally worked up, the method used was in brief as follows: The flask containing the water to be added was well jacketed, so as to make the rate change small. A series of temperature readings was taken upon both the water surrounding the bomb and the water to be added and the rate of change of each system determined. The water was then added through a jacketed glass tube, the loss from radiation and from warming of the tube being experimentally determined and allowed for. This glass tube was attached to a thin brass tube flattened at the lower end to fit closely to the calorimeter and the opening so fixed as to deliver the water against the bomb, directly downward or outward. The length of this brass delivery tube was adjusted so that in some of the experiments the water was delivered about the middle of the bomb and in others at the bottom. After the addition of the water another series of readings was taken and from the temperature change and the amount of water added, the water equivalent of the apparatus calculated.

One series of seven determinations by adding colder water gave as the water equivalent 466 calories, the greatest variation of any single determination being within ten calories of this value. Another series of 16 determinations by adding warmer water gave an average for the water equivalent of 444 calories with extreme variations of 30 calories above and below this average. The average value of the two series is 455 calories. In this method the multiplication of errors makes the value for any individual determination very uncertain and the large difference between the results from adding colder and warmer water makes the average value rather unsatisfactory and uncertain, and our experience is not such as to cause us to recommend this method as an easy or satisfactory method for determining the water equivalent.

Third Method: Varying the amount of water used to surround the bomb during the combustion: Three series of determinations were made by this method using approximately 2100, 2400, and 2700 grams of water, but the results obtained were not satisfactory. In this method as in the previous method, the multiplication of errors during a determination makes the values obtained for any single determination very uncertain, and a considerable number of determinations must be made for each series to obtain an average at all satisfactory.

A possible variation in the actual working water equivalent of the calorimeter when different amounts of water are used makes the accuracy of the results obtained by comparison of the different series uncertain. With less water than usual more of the bomb, bucket and stirrer are out of direct contact with the water and the effective water equivalent is lower than when more water is used and correspondingly large amounts of the bomb, bucket and stirrer directly in contact with it. The extreme difficulty of securing satisfactory results, the effects of small changes in the water equivalent and the effects of errors of temperature readings may be shown best by a particular example:

With 2100, 2400 and 2700 grams of water in the calorimeter, the water equivalent of the apparatus may be represented by X, X′ and X″. During a determination a small amount of the temperature change is always caused by combustion of the iron wire fuse and the formation of a small amount of nitric acid (about 30 calories of heat developed by the two). The total water equivalent of the system 2100+X, 2400+X′, or 2700+X″ is approximately known, so that the temperature deduction due to these 30 calories can be allowed for to an accuracy of within .0001 of a degree. Deducting this temperature correction from the total temperature change and letting t=corrected temperature, the temperature due to combustion of material taken, the equation for the calories of heat developed by combustion of the material is:

(1) $t(2100 + X)$
(2) $t'(2400 + X')$
(3) $t''(2700 + X'')$

Suppose with 2100 grams of water in the calorimeter the water equivalent is Y calories lower and with 2700 grams of water is Z calories higher than with 2400 grams, then $X = X' - Y$ and $X'' = X' + Z$.

The water equivalent of the Mahler calorimeter varies with each particular bomb, but ranges from about 450 to 500 calories.

Suppose X' be taken as approximately 500 and suppose that the calories of heat developed by the combustion of material used to be 8700 calories, then

$t' = 3$ degrees, and

t and $t'' =$ approximately 3.346 and 2.719 degrees.

Substituting for X and X'' $(X' - Y)$ and $(X' + Z)$ and equating 1 and 2,

$$X' = \frac{2400t' - 2100t + Yt}{t - t'}$$

Equating 1 and 3

$$X' = \frac{2700t'' - 2100t + Yt + Zt''}{t - t''}$$

Equating 2 and 3

$$X' = \frac{2700t'' - 2400t' + Zt''}{t' - t''}$$

$t - t' =$ approximately .346.

$t - t'' =$ approximately .63 and

$t' - t'' =$ approximately .28.

If $Y =$ one calorie,

$$\frac{Yt}{t - t'} = \frac{3.346}{.346} = \text{approximately 10 calories.}$$

Also if $Z =$ one calorie,

$$\frac{Yt + Zt''}{t - t'} = \frac{3.34 + 2.719}{.63} = \text{approximately 10 calories.}$$

and

$$\frac{Zt''}{t' - t''} = \frac{2.714}{.28} = \text{approximately 10 calories.}$$

In each case a variation of only one calorie in the water equivalent makes an error of +10 calories in the determination of the water equivalent.

There is no satisfactory and easy way of determining just how much the water equivalent does change with changes in amounts of water used, but the above values show that it may have a serious effect upon the actual figures obtained.

Further inspection will serve to show that the magnitude of the probable temperature errors also has an important effect upon the values obtained. The closest temperature readings on the thermometer are about .002 of a degree and an accuracy in the value of the temperature

readings in any series to within an error of less than .001 of a degree, certainly stands for extreme care and skill in manipulation and for very successful elimination of the errors incident to the use of the mercury thermometer. The effect of an error of .001 of a degree upon X′ by 1 and 2 is approximately

$$\frac{300 \times .001}{.34} = \text{approximately 10 calories;}$$

by 1 and 3

$$\frac{600 \times .001}{.63} = \text{approximately 10 calories;}$$

by 2 and 3

$$\frac{300 \times .001}{.28} = \text{approximately 10 calories.}$$

From this alone it is apparent that extreme accuracy by this method is not to be expected and taken together with the uncertainty due to the possible changes in the water equivalent the results obtained from this method can hardly be considered as very satisfactory.

Fourth Method. Electrical Standardization: This method depends upon the conversion of electrical energy into heat and involves the measurement of the electrical energy introduced and the temperature effect upon the calorimeter. The accuracy of the results obtained are dependent not only upon the accuracy of the measurements of the electrical units but also upon the absolute accuracy of the electrical units themselves. The writer has as yet not used the method, and hence has at present no comparative water equivalent values to offer. However, the very high grade instruments required in making the measurements puts it beyond the reach of most commercial and technical laboratories, and the most satisfactory available and the most commonly used is the next or fifth method.

Fifth Method. Calculation of the Water Equivalent from the Temperature Changes Produced by Combustion of Definite Amounts of a Material of Known Calorific Value: This is comparatively easy and there is no multiplication of errors, as in some of the other methods, and closely agreeing values are not extremely difficult to obtain. There are, however, some difficulties, one of which is to know the exact calorific value of the material used.

Naphthalene. This substance is quite commonly used as a standardizing material and has been taken as the standard for determining the water equivalent of the calorimeters used in determining the calorific values given for the samples of coal published in this report. Different lots of naphthalene differ quite considerably in calorific value, and the most satisfactory grade that the writer has been able to obtain is Kahlbaum's C. P. material. Merck's highest purity medicinal is not regarded as entirely satisfactory for calorimetric work, one lot running fifty to

sixty calories lower than the Kahlbaum material. The results on another lot of Merck's, apparently of the same grade but put up with more care, checked the results on Kahlbaum's reagent almost exactly.

The value of the water equivalent obtained for the calorimeter depends not only upon the purity of the naphthalene but also upon the figure taken as its calorific value, two quite different values being ascribed to it. Berthelot's value—9692 calories—has been used by Professor Lord and the writer for all standardization work, this value being used by Mahler. Stohlman gives as the calorific value 9628 calories and this value is used by Atwater. Using Kahlbaum's naphthalene and Berthelot's figure for calorific value, the water equivalent of the particular calorimeter previously mentioned is 460 calories. Using Stohlman's value it is only 441 calories. By using some lots of medicinally pure naphthalene the results for the water equivalent are about twenty calories higher than were obtained from the Kahlbaum naphthalene.

Benzoic Acid. The value given by both Berthelot and Stohlman for this material is 6322. Different lots of this substance may differ slightly in calorific value. Tests upon the best acid from gum benzoin gave results averaging a few calories lower than were obtained upon Kahlbaum's chemically pure matetrial. Using chemically pure acid the average from ten determinations is 443 calories for the water equivalent of the calorimeter. The average of three other determinations by another operator is 451 calories. The value from three determinations upon acid from gum benzoin is about 450 calories. From another series of five determinations run at a different time upon a different lot of acid from gum benzoin obtained from the same chemical supply house, but which had been standing around the laboratory for a year the value obtained for the water eqiuvalent is about 467 calories.

Cane Sugar. The values given by Stohlman and Berthelot agree within ten calories on this material, the average being 3958. One slight objection to cane sugar is that it does not ignite very readily and on this account in making a determination it is necessary to use a small amount of naphthalene or some other material of high calorific value to act as a kindler in starting the combustion.

Using ordinary granulated sugar: From one series of seven results the value obtained for the water equivalent is approximately 470 calories. Two results run on the same material by a different operator at a different time indicate approximately 467.

Using crystallized rock candy, one series of six results gave a value of about 455 calories as the water equivalent.

Collecting the different values:

(1)	By estimation from specific heats		470
(2)	By adding cold water	466	
	By adding hot water	444	
	Average	455	455

(3)	By using different amounts of water during a combustion, results ranging from ....400 to	500
	Not satisfactory.	
(5)	Burning material of known calorific value: — Kahlbaum's naphthalene (using 9692 as calorific value).....................	460
	Kahlbaum's naphthalene (using 9628).........................	441
	Benzoic acid (calorific value 6322) Kahlbaum's C. P............	443
	Highest quality from gum benzoin ....450 to	467
	Cane sugar (calorific value 3958) Commercial granulated sugar ....467 to	470
	Crystallized rock candy	455

This series of values to the inexperienced in calorimetric work may look rather ragged, but the writer believes that it is in full accord with the experience of chemists who have done large amounts of calorimetric testing extending through considerable periods of time, and the differences are given to call attention to the danger of determining the water equivalent in only one way, or upon only one lot of material. Some, but not all, of the differences in the values given are attributable to actual differences in the materials tested.

The differences in results obtained at different times on the same material are attributed by some chemists to differences in the quality of oxygen used; however, tests made at different times by the writer upon different lots of oxygen have in all cases indicated the absence of appreciable amounts of combustible impurities, and it appears that the different results given for the same materials are to be accounted for in some other way. In cane suar some of the high results are possibly due to failure of traces of the sample to burn completely, as with the shallow tray, usually used with a Mahler calorimeter, failures of cane sugar to burn completely are not infrequent. A deeper tray would very probably greatly decrease the number of unsatisfactory determinations.

The oxygen used in all calorimetric work done by the writer or under his direction has been furnished either by Arthur Hawkridge of Hoboken, New Jersey, or The White Dental Company of Philadelphia, Pa. The quality furnished by both of these manufacturers has so far been satisfactory.

As has been stated, the water equivalent used in the work upon coals is based upon Berthelot's value of 9692 for naphthalene and using Kahlbaum's C. P. material. In the series of values given, this value—460—is intermediate between the extremes of the values obtained from other substances or by other methods. The difference between the extreme values of 470 by specific heats and 443 from benzoic acid or 441 from Stohlman's value for naphthalene calculated to percentage effect on coals tested is equivalent to a difference in results of about nine-tenths of one per cent. That the actual water equivalent is between these extremes appears very probable and in the opinion of the writer, using 460 as the water equivalent of this particular calorimeter, the calorific value

obtained for the fuels tested should be correct to within an error of a few tenths of one per cent. Taking into consideration what has already been given, it is hoped that the expression of this opinion will not subject the writer to the criticism that he under-estimates the difficulties of accurately determining the actual water equivalent of a calorimeter.

CALCULATING AND REPORTING OF RESULTS.

The analysis and calorific value of each of the samples is given in connection with the sections of the seams in that portion of the report prepared by Dr. Bownocker. These analyses are for further comparison and discussion tabulated at the end of the chapter, written by Professor Lord, the results on the samples of each of the different seams being grouped together. The analyses on the samples of Nos. 4, 5, 6 and 7 coals collected during 1900, 1901, and 1902 are all upon the partially air-dried samples. These results, as has already been stated under the "Method of Sampling," are therefore all lower in moisture than the sample as mined, while the calorific value, sulphur and ash are correspondingly higher. The samples of No. 8, 8a and 9 coals collected in 1907 are all reported upon the sample as received at the laboratory. Being shipped from the mine to the laboratory in sealed cans, the analysis is therefore upon the sample as mined.

On air drying under ordinary weather conditions, these coals all lose moisture and the results as given are higher in moisture and lower in calorific value than the values obtained upon the air-dried sample. "Air-dried Sample" is, however, such a variable quantity depending upon the particular temperature and humidity conditions existing at the particular time the sample is handled that an effort to report the samples upon an air-dried basis is not very satisfactory.

The chief value of air drying a sample before analysis is to obtain the sample in such a condition that its variations in the laboratory while being analyzed are small. The air drying loss is, however, an approximate guide to the loss that the coal may suffer during shipment. The foot-note values give the approximate moisture in the air-dried sample. The difference between the moisture in the sample as received and the moisture in the air-dried sample indicates the possible loss which the coal may undergo before arriving at an air-dry condition in ordinary summer weather. Complete air drying of a shipment, is, however, the exception rather than the rule, as lump coal or coal in piles of any considerable depth holds a considerable amount of this excess moisture even in dry weather, and in damp weather the loss is of course small, and in very wet weather the moisture content may often exceed the moisture content in the coal as mined, especially if exposed to rain or snow, and if a shipment contains much slack coal.

As the samples collected during 1907 are all reported upon the

sample as mined, if the results are compared with the earlier samples taken or with analyses of samples as ordinarily shipped, this fact must be taken into consideration in making the comparision. The results obtained upon the samples collected during 1907 show that the moisture content of the coal as it occurs in the mine varies very considerably. In the No. 9 coal it ranges from 3 per cent. to 5.3 per cent., the average being about 4.1 per cent. In the No. 8a coal it ranges from 3.4 per cent. to 8.2 per cent., the average being about 6.8 per cent. In the No. 8 coal it ranges from 2.8 per cent. to 7 per cent, the average being about 4.7 per cent. In the samples of No. 6 coal taken during 1907, the moisture ranges from 3.6 per cent. to 8 per cent., the average being about 6.3 per cent. In the samples of No. 5 coal, the range is from 2.5 to 8.4, the average being about 6 per cent.

After air drying the moisture still contained in the samples averages for the No. 9 coal about 2 per cent., in the No. 8a coal about 4 per cent., in the No. 8 coal about 3 per cent. and in the No. 5 and No. 6 samples tested about 2.5 per cent.

The heating values of the samples are all given in calories. For discussion of the relation of the calorie to the British thermal unit, see chapter by Professor Lord, page 267. For explanation of the meaning, use and value of "H," see same chapter, page 268. For explanation of the calculation of the heating value from the ultimate analysis by means of Dulong's formula, see same chapter, page 267.

Special Tests for Air-Drying Loss. To determine the rate and extent of air-drying loss upon exposure to the ordinary air of the laboratory, special tests were made upon several samples. The original samples crushed to ¼ inch were weighed upon trays 24x24 inches and allowed to stand at room temperature for a number of days. Weighings were made from time to time and the temperature and humidity at the time of the weighings reported. Two samples dried for ten days, one of No. 8 coal, sample No. 26, and one of No. 9 coal, sample No. 53, gave results as follows:

Sample No. 26:

Time between Weighings.	Weight	Temperature.	Humidity.
	1500 grams	26	67
3 days	1465 "	23	53
1 day	1455 "	24	18
1 day	1441 "	24	49
1 day	1441 "	23	53
4 days	1441 "	24	54

The total loss in the ten days is 59 grams, equal to 3.93 per cent. This coal still contains by analysis 3.65 per cent. moisture. Sample No. 53 as received contained 2.95 per cent.; dried to constant weight under the same conditions as No. 26, the air-dried sample contained 1.66 per cent. moisture.

In the regularly analyzed samples dried in the drying oven the moisture contained in the air-dried samples ranges in the No. 9 coal between 1½ and 3 per cent., in the No. 8a coal between 3½ and 4½ per cent., and in the No. 8 coal between 2 and 4 per cent.

Tests for air drying loss and moisture remaining in air-dried samples were also made upon portions of three samples of No. 5 and No. 6 coal with the following results:

Time between weighings. Hours.	Temperature.	Humidity.	Sample No. 826.		Sample No. 76		Sample No. 138	
			Wt.	Loss.	Wt.	Loss.	Wt.	Loss
0	21½	32	2907	0	3029	......	2043	....
6	23	30	2850	57	2972	57	1986	57
16	22	31	2807	43	2918	54	1957	29
24	25	27	2784	23	2987	31	1943	14
48	20	50	2776	8	2982	5	1951	8
24	20	33	2773	3	2978	4	1943	8
118				134		151		100

The total time of air drying was 118 hours and the total loss of each sample is as follows:

Sample No. 826.
134 grams loss equals 4.60 per cent.
Sample No. 76.
151 grams loss equals 4.98 per cent.
Sample No. 138.
100 grams loss equals 4.89 per cent.

The air-dried portions of these samples still contained moisture as follows:

Sample No. 826.	3.41 per cent: Moisture.
Sample No. 76	3.20 per cent: Moisture.
Sample No. 138	2.32 per cent: Moisture.

In the regularly analyzed samples of No. 5 and No. 6 coal collected during 1907, which samples were air-dried in the drying oven, the moisture in the air-dried samples ranges from 1½ to 3 per cent.

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